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MELVILLE T. COOK, EDITOR

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INFLUENCE OF SMOKE AND ETHYLENE ON THE FRUITING OF THE PINEAPPLE (ANANAS SATIVUS SHULT)*

ANTONIO G. RODRÍGUEZ,

The pineapple is one of the principal export crops of Puerto Rico. The large crop months are May, June and July. These unfortunately, are the peak months for the Cuban crop. As might be expected, therefore, there are times when the American market receives more pineapples than can be profitably sold. If the season of production of pineapples could be extended so that a larger proportion of the fruit could be ready for the American market in advance of the usual time, the economic situation would be improved. It was with these ideas in mind that this investigation was undertaken.

An immediate stimulus to the direction of this investigation was the fact that one of the important growers in Puerto Rico was shipping his pineapples to the American market some months in advance of the other growers. From observations and from discussions with this grower and others, it appeared, that the only departure in cultural methods made by this grower was the use of smoke to hasten the flowering of the pineapple. In practice this grower covers a small part of the pineapple field with a tent of loose cloth. Within this tent smudge fires are provided and smoke production allowed to continue for twelve hours. Flower and fruit production follow in a shorter period of time than usual.

Assuming these as facts, consideration was given to the possible stimulating agent in the smoke responsible for this rapid forcing of the plants. From the fact that ethylene is produced in destructive distillation of wood and that ethylene has been found to be effective as a forcing agent, it seemed logical to test not only the smoke but to modify the practice so as to include treatment with ethylene gas. An added incentive to determine the possible influence of smoke and ethylene gas was the recognized practice of the use of smoke in certain areas in the Philippine Islands to force the Mango tree into flower.

* Presented to the Faculty of the Graduate School of Cornell University in partial fulfilment of the requirements for the degree of Master of Science.

This practice of smoking the Mango tree (*Mangifera indica* Linn.) has been described by González (**5**). Smudges are built on the ground, under the trees, a few meters from the trunk. These smudges consist of conical piles of light combustible material, with a cover of moist or green grass on the top. When ignited, these smudges produce a dense smoke, under which condition the trees are kept until flowering is attained.

Recently, in the island of Puerto Rico the smoking of pineapple plants to hasten the flowering has become a practice among certain growers. A portion of the field is covered with a tent as earlier described, and within this tent between the rows of pineapples, smudge fires are made; the plants being exposed to the influence of the smoke for a period of not less than twelve hours. Flower production was claimed to have been attained shortly afterwards. The origin of this practice is not yet known.

Molisch (**10**), (**11**), (**12**), Knight and Crocker (**7**), (**8**), and Bokerny (**1**) have studied the influence of smoke on plants.

Contrary to the results obtained in the Philippines and in Puerto Rico, these investigators have reported that smoke derived from the burning of tobacco, paper, straw and wood, is toxic to many plants. This suggests that the quantity of smoke per unit volume of air and the physiological state of the plant are factors of importance.

In order to make clearer the character of this investigation it seems desirable to inscribe briefly the cultural methods used in Puerto Rico. The variety Red Spanish is the most extensively grown pineapple. The popularity of the Red Spanish is due to the fact that it produces abundantly and the fruit has excellent shipping qualities. The propagation of the pineapple plant is accomplished by means of slips, suckers and crowns. Slips are shoots that originate from the buds produced at the base of the fruit. Suckers develop from the axils of the leaves, while crown slips originate at the upper end of the fruit.

Among growers in Puerto Rico slips are more popular as propagating material than suckers. It is commonly believed that suckers will produce only two crops while slips will give three crops. From suckers, a crop is obtained at the end of fourteen to sixteen months, while from slips eighteen months are required. To growers this advantage of early production is not sufficient to offset the disadvantage of the sucker producing only two crops.

The propagating material may be planted at any time of the year, but spring and summer planting is preferred by growers. Root development may begin shortly after planting but generally speak-

ing new leaf development is not apparent until five to six weeks after planting. Under favorable conditions, particularly with an adequate water supply, leaf development may occur sooner.

Normally, suckers will flower at the end of ten to thirteen months. Slips require fourteen to sixteen months to flower. With both there are irregularities, some plant flowering ahead of the usual period. Whether such unusual behavior is due to the stage of maturity of the slip when planted or to the soil and weather condition, is not yet known.

Experimental

The use of smoke to force pineapple plants into fruit production is a practical development. No controlled experimental work has been reported of this practice. For this reason it seemed desirable to determine the influence of smoke under controlled conditions.

In considering the cause of flowering of the pineapple plant following the treatment of smoke, the primary hypothesis raised was that smoke forces the pineapple plant out of a dormant condition. However it was recognized that some constituents of smoke probably ethylene might effect metabolic changes even though the plants were not in a dormant condition, which changes might conduce to floral development.

Both slips and suckers are completely developed plants. The roots at the time of planting are very short. The fact that new leaf development is retarded four to six weeks after planting suggests that slips and suckers are in a state of dormancy. It seemed probable that the use of ethylene on these might bring about an immediate resumption of growth with a consequent shortening of the time for flower production. There also remained the possibility as was realized, of a more pronounced effect of ethylene on fruit production. Accordingly an experiment was devised in which both slips and suckers were exposed to ethylene previous to planting. Such a method, if it proved successful, would obviously be a cheaper and more practical method than the use of smoke under field conditions.

I. USE OF SMOKE UNDER FIELD CONDITIONS

In these particular experiments, consideration was given to the influence of different quantities of smoke and to the effect produced as influenced by the age of the plants.

The plots for experimental purposes were selected in a field at Isla Verde, Santurce, Puerto Rico. The plants were normal in appearance and growing in a soil which consists of a fine sand under-

laid by a stratum of heavy clay impervious to water. The top five inches contained an abundance of organic matter. The soil is low in calcium, phosphorus and potassium. Natural drainage is poor and consequently artificial drainage is essential. This was provided. In general it may be stated that the soil is not well suited for crop production. To obviate variations in the plots due to soil conditions, sections were selected in the field for uniformity of soil and plants.

Each plot was one-fifth acre in area and had approximately 2,000 plants. Each plot comprised twelve rows of plants. A tentlike structure about four feet in height was constructed over each plot. The cloth used was of a loosely woven cotton, a low grade muslin. The material used to produce the smoke was placed in cans of five gallons capacity and placed within the tent. The smoke was produced by a slow combustion of the dry husk of the cocoanut fruit together with the green bud scales of the cocoanut palm. The dry husks were slightly moistened. The fuel was renewed several times during the treatment. Combustion was slow with a low flame and producing a large amount of smoke. The smoke diffused through the meshes of the cloth. The duration of the treatment was twelve hours, usually from 6 P. M. to 6 A. M.

Experiment I

In this experiment the plants to be treated had been planted seven months previously. On December 1, 1930, twelve cans were placed within the tent and the plants exposed to the smoke for a period of twelve hours.

By the latter part of December 1930 the favorable effect of smoke was apparent by the development of red pigment in the lower part of the leaves near to the growing point. This change is recognized as an indication of the flowering period. By January 3, 1931, the flower stalk had appeared and by the end of January the fruit was well formed. The fruits produced by treated plants were mature and harvested in March 1931. The fruits obtained from the controls were harvested two months later. Practically every plant in the treated plots responded to the smoke treatment. The fruits were of marketable size and of quality equal to the fruit produced by untreated plants. The even bearing of the treated plants is shown in figure 1.

Plants adjacent to treated plots and which were under the influence of the smoke diffusing out of the tent also flowered.

One of the treated plots in this experiment did not flower. It was found, however, that the laborers had not given proper attention to the fires and the plants received only an eight-hour treatment.

Experiment II

An entire section of pineapple field, which had not flowered after twenty months of growth, was selected to test the influence of smoke in forcing plants to flower. Sections of two thousand plants each was covered with a tent and smoked for a period of twelve hours. The concentration of the smoke within the tent was increased by using twenty cans of the burning material.

Flowering was noted six weeks after the smoke was applied. Through a misunderstanding, the entire field was treated and no controls left. It was noted, however, that the plants showed no signs of approaching flowering at the time of treatment. As stated previously, when the pineapple plant is near to the flowering period, the lower part of the inner leaves near to the growing point becomes red. This coloration usually appears approximately eight weeks before flowering. Such signs were not observed in this section prior to the treatment, and from the fact that all plants flowered and fruited at the end of six weeks, after treatment, it is probable that the smoke was effective.

Experiment III

In the third experiment, plants which had already given one crop of fruit and which were about twenty-four months old were treated with smoke for twelve hours in the usual way. The experiment was varied so as to include different concentrations of smoke. Such concentrations were adjusted by using different numbers of cans producing the smoke. Sections were provided in which 8, 12, 16 and 20 cans of the burning material were used respectively. The plants were treated on November 24, 1930. Normally these plants would not have flowered until late in February. By treating them with smoke regardless of the number of cans used to produce the desired concentration, all flowered early in January, six weeks after the treatment. Sections left as checks had not flowered up to April 1931. The experiment is still in progress.

II. TREATMENT OF SLIPS AND SUCKERS BEFORE PLANTING WITH ETHYLENE AND SMOKE

Since ethylene is a product obtained during destructive distillation of wood, and since it has been used as a forcing agent in the

fields of Floriculture, Pomology and Vegetable Crops it was also tried as a forcing agent for pineapple cuttings with a view to developing a better method than the smoke treatment.

Mature slips and suckers were placed in a closed room and ethylene gas applied in two different concentrations, one part of gas to eighty parts of air (1:80) and one part of gas to two hundred parts of air (1:200). Gas was supplied every day at eight o'clock in the morning and at six in the afternoon. The room was ventilated for about half an hour before a new application of gas. These treatments lasted one week, at the end of which time slips and suckers were planted and observations of growth and development of roots were made. Checks were held as close to the same conditions of temperature humidity and light as could be obtained. A larger number of slips were used because they are preferred by planters as propagating plants.

The treated slips and suckers were planted August 16, 1930 in the experimental plots of the Insular Experiment Station of Puerto Rico. The number of plots and treatments are as follows:

6 plots of slips—1:80 treatment
6 plots of slips—1:200 treatment
4 plots of suckers—1:80 treatment
3 plots of suckers—1:200 treatment
3 plots of slips untreated—controls
3 plots of suckers untreated—controls

Each of these plots contains twelve plants. The control plots were scattered among the treated plots as can be seen from Table I.

Smoke was also used on slips before planting. They were placed in a closed room and treated with smoke for a period of ten hours. The smoke was obtained from smudge fire built in the same room. Wood was used as the combustible material to produce the smoke. This material was covered with green grass and sand to insure slow combustion.

For plants treated with ethylene and smoke before planting, no fertilizers were used. The plants were left entirely to develop with the natural fertility of the soil.

I. RESULTS

The slips and suckers treated with ethylene were planted August 16, 1930. The treated slips were turning yellow and appeared more dry than the controls at the time of planting, especially the ones to which the high concentration of the gas had been given. The young plants were favored by rain during the first and second weeks after

planting. Controls and treated plots showed no difference in root development or growth during the first weeks. In general the control plants appeared more vigorous.

No data on growth were taken until five months later when all treated plants had fruited. These plants had flowered at the end of three months after planting. The results presented here were taken during the last week of January 1931, when many treated plants had well matured fruits. When the fruits were harvested the plants were six months old. Up to this time none of the plants in the control plots had bloomed. The experiment is still in process. By May 1, 1931, nine months after planting only two of the control plants derived from suckers had flowered.

None of the plants which had been exposed to smoke previous to planting showed any appreciable response to the treatment. The smoke-treated plants were in appearance similar to the plants in the control plots. The experiment is still in progress and it remains to be determined if this treatment will prove of value.

The results obtained from the treatment of the slips and suckers with ethylene are of unusual interest. Generally plants from suckers will not flower until nine months after planting while plants produced by slips flower only after thirteen months. With these ethylene treated plants, flowering was noticed three months after planting. Not all of the treated plants had produced fruits by February 1931. These results are presented in Table I. It is not yet possible to state definitely the flowering dates of the untreated plants, but it may be stated that the treated plants flowered at least six months before the control plants.

These results are significant in one other respect. Generally plants derived from suckers flower before those produced from slips. In this particular experiment the ethylene-treated slips and suckers flowered at the same time. This fact is of special significance as will be developed subsequently. While the plants derived from slips flowered as soon as the suckers the latter produced larger fruits. These differences are brought out clearly in Table II and representative fruits are shown in Plate II.

The fruits produced by these treated plants were in general undersize and of no commercial value. It should be remembered that no attempt was made to provide favorable conditions for plant growth by the addition of fertilizers.

TABLE I

NUMBER OF PLANTS THAT PRODUCED FRUIT BY FEBRUARY 1931

Plot No.	Treatment	Number of Plants that Fruited	Number of Plants that did not fruit
1	Ethylene—1:80	Slips	4	8
2	Control——	Suckers	0	12
3	Ethylene—1:200	Slips	9	3
4	Ethylene—1:80	Suckers	4	8
5	Ethylene—1:80	Slips	4	8
6	Control——	Slips	0	12
7	Ethylene—1:200	Suckers	6	6
8	Ethylene—1:80	Suckers	5	7
9	Control——	Suckers	0	12
10	Ethylene—1:200	Slips	7	5
11	Ethylene—1:200	Slips	6	6
12	Ethylene—1:80	Slips	5	7
13	Control——	Slips	0	12
14	Ethylene—1:200	Slips	4	8
15	Ethylene—1:200	Suckers	5	7
16	Ethylene—1:80	Suckers	3	9
17	Control——	Suckers	0	12
18	Ethylene—1:200	Suckers	7	5
19	Ethylene—1:80	Suckers	4	8
20	Ethylene—1:80	Slips	4	8
21	Control——	Slips	0	12
22	Ethylene—1:200	Slips	5	7
23	Ethylene—1:80	Slips	1	11
24	Ethylene—1:200	Slips	6	6

TABLE II

AVERAGE WIDTH AND HEIGHT OF FRUITS PRODUCED BY SLIPS AND SUCKERS

	Slips			Suckers	
	Average Width of Fruit in inches	Average Height of Fruit in inches		Average width of Fruit in inches	Average Height of Fruit in inches
1	1.43	2.31	4	2.93	3.75
3	1.44	2.41	7	3.04	3.91
5	1.42	2.19	8	3.15	3.80
10	1.57	3.43	15	2.45	3.20
11	1.53	2.32	16	3.25	3.66
12	1.75	2.75	18	2.67	3.50
14	1.87	2.62	19	3.17	3.93
20	2.06	2.81	.....	.....	.....
22	2.20	2.85	.....	.....	.....
23	1.00	2.00	.....	.....	.....
24	1.62	2.50	.....	.....	.....
Average	1.62	2.47		2.95	3.67

II. INFLUENCE OF CONCENTRATION OF ETHYLENE ON FRUITING

Slips and suckers as previously stated were given two different treatments with ethylene. One lot was exposed to ethylene at a concentration of one part of gas to eighty parts of air, the second lot was exposed to one part of gas to two hundred of air. The data in Table III suggests at least, that the earlier fruiting was obtained

with the concentration of one to two hundred. This was true for both slips and suckers. The experiments should be repeated before definite conclusions are warranted.

III. INFLUENCE OF CONCENTRATION OF ETHYLENE ON THE SIZE OF THE FRUIT

A comparison was made of the influence of the concentration of ethylene on the size of the fruit. The data show that the size of the fruit was not significantly influenced by the concentration of ethylene. The summarized data are given in Table IV.

TABLE III

INFLUENCE OF CONCENTRATION OF ETHYLENE ON THE NUMBER OF PLANTS THAT FRUITED BY FEBRUARY 1931

Plot No.	Concentration 1:80	Concentration 1:200	Plot No.	Concentration 1:80	Concentration 1:200
1	4		4	4	
3		9	7		6
5	4		8	5	
10		7	15		5
11		6	16	3	
12	5		18		7
14		4	19	4	
20	4				
22		5			
23	1				
24		6			
Average	3.6	6.2		4.0	6.6

TABLE IV

CONCENTRATION OF ETHYLENE ON SIZE OF THE FRUIT
ALL PLOTS CONSIDERED

Concentration Ethylene	Slips		Suckers	
	Average width in inches	Average Height inches	Average width in inches	Average Height inches
1:80	1.53	2.41	3.10	3.78
1:200	1.70	2.52	2.72	3.53

OTHER EXPERIMENTS

In addition to the various experiments described in the preceding pages, slips and suckers were shipped to Ithaca in October 1930. These were treated with ethylene, ethylenechlohydrin, dichlorethylene and trichlorethylene at a concentration of 1 : 1000, and planted singly in nine-inch pots in an Ontario Silt Loam. These plants were kept in a greenhouse at a temperature close to 80°F. Unfortunately these

plants have made but little growth under these conditions. A similar lot was brought back from Puerto Rico in February 1931 and treated in a similar manner. Sufficient time has not yet elapsed to permit any conclusions. In Puerto Rico during the month of February new experiments were started with various treatments, both with slips and suckers before planted and with plants under field conditions. These results will be reported at a later date.

Discussion

The use of smoke on plants in the field resulted in a very general flowering of all plants and subsequent early fruit production. The experiments confirm the results obtained in practice by certain growers in Puerto Rico. However, additional experiments are necessary to determine more precisely the essential conditions. The fact that in certain experiments no relation was found between the quantity of smoke used and the response obtained makes it appear probable that there is a wide latitude in this respect. A similar latitude has been noted in the use of ethylene on slips and suckers.

The experiments using ethylene gas on slips and suckers while not yielding uniform results, nevertheless forced plants into flower in about three months instead of after a year or longer. Fruit production was exceptionally early and although the size of the fruit was small it seems possible to increase this by the proper use of fertilizers.

The fact that the ethylene treatment of slips and suckers did not result in a simultaneous flowering of all plants indicates that the physiological condition of these plants must be given consideration in further investigations. From the practical standpoint this failure of uniformity in the time of flowering may be desirable since it enables a longer season for selling fruits.

As yet no analysis have been made to determine the chemical changes occurring in field plants following the smoke treatment, nor for those plants which had been treated with ethylene before planting. González (5) maintained that the effect of smudge fires on the Mango tree (*Mangifera indica*, Linn.) was a temperature effect. Since the fires are maintained for long periods of time temperature may possibly be a factor but at the same time there is a possibility that this forcing effect may be due to the hydrocarbon gases evolved during the combustion. In a slow combustion of wood, straw, or any other organic material there is a destructuve distillation process, in which process various hydrocarbon gases are formed such as acetylene, ethylene, propylene, etc. It is obvious, therefore, that attention must be given to these gases as possible forcing agents.

In the experiments in which the pineapple plants were exposed to smoke under a tent for a period of twelve hours, the combustion was slow and the heat produced was little and could have elevated the temperature but slightly. The temperature increase would be no greater than that commonly experienced during normal conditions. The fact that plants outside the tent, but exposed to the diffusing smoke, also flowered suggests that the constituents of the smoke and not the temperature produced during combustion were responsible for the hastening of the plants into bloom. This view that a gas or gases are the forcing agents is supported by the results obtained from the use of ethylene on slips and suckers before planting.

One other distinct aspect of the problem should be emphasized. Does smoke shorten a resting period in the pineapple? It has been demonstrated that most biennial and perennial plants exhibit a definite resting condition. Thus the question arises: does the pineapple plant enter a period of rest previous to flower production? There is, however, no apparent cessation of vegetative growth before flowering occurs. This suggests that the plant is not in a resting condition. The effect of smoke must, therefore, be to influence metabolism in such a way as to force the meristem into reproductive growth. Harvey (6), Denny (4) and other have demonstrated that ethylene treatments are followed by a conversion of stored food to available food. It is possible that in this experiment with smoke such changes occur in the pineapple with a resulting change in the soluble carbon nitrogen, ratio, which changes might induce flower production.

In support of this view are the results obtained from the treatments of slips and suckers with ethylene. These normally do not produce new leaves until six weeks after planting at the maximum; therefore, the resting condition could not prevail for more than six weeks. On the basis of overcoming the resting condition with ethylene, the time for flower production in the pineapple should have been shortened about six weeks. As a matter of fact the saving in time was more than six months in the more favorable cases. These results point to the conclusion that the ethylene treatment has modified metabolism in such a way as to induce also flower production. This principle, if correct, should prove to be one of paramount importance both for purely scientific as well as from the practical stand-point.

In previous work, except for that of González (5), attention has been given largely to the toxic action of smoke on seedlings. Molisch (10), (11), (12), has shown that tobacco smoke is very toxic to many plants and that smoke produced from paper, straw and wood has the

same effect. On the basis of his data he concludes that carbon monoxide is probably the constituent determining the toxicity of tobacco smoke. Nejubow (13), Crocker (2), (3), Lehman (9), and Knight and Crocker (7), (8), have reported that ethylene is toxic to epicotyls of certain seedlings and to other plant organs. According to Crocker (2), (3), ethylene seems to be the predominant toxic agent evolved during destructive distillation. Bokorny (1) attributes the toxicity of tobacco smoke to the ammonia produced during burning. It is possible that under certain conditions smoke may be injurious to pineapples. In these experiments and in practice the plants are exposed to smoke during the hours of darkness when the stomates are practically closed. Under this condition only a small amount of gases may enter. Perhaps if the smoke treatment were given during the day time, especially in the morning, a much shorter treatment would give the same results.

In future treatments of slips and suckers with ethylene, consideration should be given to humidity and temperature relations. Histological studies to determine the time of flower production should also be made.

In conclusion it should be stated that both smoke and ethylene treatment of slips and suckers hold great promise for controlling the time of fruit production of pineapples. It is probable that under tropical and semi-tropical conditions that these methods may find application for other fruits and flower crops.

SUMMARY

1. The experiments using smoke on pineapple plants in the field confirm the results obtained in practice by certain growers in Puerto Rico. The use of this process in the field resulted in a general flowering of all plants and early fruit production.
2. There was no relation between the quantity of smoke used and the response of plants. This indicates a wide latitude as regards concentration of smoke.
3. The age of the plants was not a factor hindering the effect of smoke treatment.
4. From the results obtained in the smoke treatments and ethylene treatments it seems that one or more constituents in smoke and not the temperature produced are responsible for the hastening of bloom.
5. Under the conditions in which smoke treatments were given to field plants, smoke was not toxic.
6. Large-size fruits were obtained following the smoke treatments.
7. The treatment with smoke previous to planting gave no appreciable response.

8. Slips and suckers treated with ethylene previous to planting flowered six months before the control plants.
9. Fruits obtained from ethylene treatments were undersize. Suckers yielded larger fruits than slips.
10. No significant difference was noted with the several concentrations of gas when used on slips and suckers.
11. The results obtained indicate that the ethylene treatment has modified metabolism and induced flower production.

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ILLUSTRATIONS

Plate I.—Left: Pineapple plants treated with smoke seven months after planting. Right: Control plots.

Plate I.—Representative fruits obtained from slips and suckers treated with ethylene.

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PLATE I.

PLATE II.

INHERITANCE OF COLOR IN THE EGGPLANT

(*Solanum melongena* L)[1]

J. A. B. Nolla[2]

The purpose of this investigation has been to obtain some knowledge of the behavior of color of our so-called native eggplants toward that of the imported Black Beauty and New York Improved as this would be very useful in connection with simultaneous studies on the production through hybridization of eggplants resistant to the bacterial wilt (*Phytomonas solanaceara* (E. F. Sm.) Comm. S.A.B.). The Black Beauty is generally very susceptible to this disease, but it was discovered in preliminary trials by the author in 1923 and 1924 that one of the native varieties was more resistant to the disease than any of the imported varieties. However, this native fruit is of undesirable color and shape for commercial purposes.

The factors which have been studied in this investigation are: color of plant, of fruit and of flower, and the striped character of the anthers.

The first studies on eggplant hybridization seem to have been made by Bailey and Munson (**3**) and were reported in 1891. The results published then were on the F_1 generation and showed that purple color of both fruit and foliage is dominant over green. In the following year Professor Bailey (**2**) gave results of some F_2 and backcross data. In a progeny of 175 plants from a self-fertilized F_1 individual he found 83 green and 92 purple plants, a result which would indicate a 9:7 ratio. According to this ratio, two factors should be assumed for color of plant both of which would be necessary for the development of purple color. In the same F_2 population 102 plants came into fruit, 48 of which were colored and 54 green or white. These numbers are contradictory since greens appear to be in excess of purples. It is plain that the numbers were too small to give conclusive results; a larger population would have been more reliable. In two other F_1 fruits A5 and A6, self-pollinated like the preceding one, the results taken together show 299 purple plants to 208 recessive, another indication of a 9:7 ratio.

[1] Presented as a partial fulfillment of the minor requirements for the degree of Doctor of Philosophy at Cornell University.

[2] Formerly of the Insular Experiment Station, now in the Graduate School at Cornell University, Ithaca, N. Y.

In a fourth F_1 fruit (A8), not artificially pollinated nor bagged, the resulting F_2 generation gave 105 purple and 69 green plants. This was presumably naturally selfed although it may have been pollinated by insects. Here again, like the preceding, the results appear to indicate a 9:7 ratio for plant color.

In the backcross results conditions are, in a way, different. The backcross progeny of A 2 gave 82 green plants and 21 purples, that of A7 gave 101 greens to 143 purples. These should be expected to be similar in both progenies, but this is not the case. In the former, a 1:3 backcross ratio confirms the 9:7 ratio in the F_2. In the latter, however, the purples are in excess of the greens, an observation which appears to be contrary to the expected 1:3 ratio.

The results of fruits A 3 and A 4 which were the product of the pollination of F_1 with the dominant Black Pekin, are as would have been expected, all purple plants.

Finally, the results for the eight progenies are given together, and are therefore of no value from the standpoint of the analysis of color.

Two other crosses, Giant Round Purple × White Chinese and Long White × Black Pekin, are also reported but the populations in all of the F_2 or backcross progenies are too small to be of value in determining ratios.

Munson (**6**) in 1892 reported further on the above crosses. This same writer, later in 1905 (**7**) commenting on eggplant crossing further reaffirms the dominance of purple color of fruit over white; but makes no other contribution to the knowledge of inheritance in this plant. It must be remembered that Mendel's epoch-making studies on inheritance had already been discovered at the time of this later publication.

Owen (**9**), in 1912 reported on the F_2 generation data of cross Long White × Dwarf Purple and in a population of 90 plants found 59 with purple stems to 31 with green stems.

Here again a 9:7 ratio shows a behavior for plant color similar to that reported by Bailey and Munson. It is of interest to note that all the green-stemmed plants bore either greenish white or ivory fruits, colors which are recessive to purple or violet. This indicates a possible linkage of recessive factors for plant and fruit color or a single gene that affects both plant and fruit color. The purple-stemmed plants bore purple or violet fruit.

The same writer (**10**) again in 1917 gave some data on F_2 generations of crosses made in previous years but the numbers are very

small. He, however, points again to the dominance of purple color of fruit over green.

Halsted (**5**) found a 3:1 ratio of green to white color of flesh and a similar ratio of purple to colorless skin (Green purple × White colorless). In the cross Long White × Dwarf Purple he obtained a 9:3:3:1 ratio of purple, green, pink and white skin. For this proportion a two-factor hypothesis should be assumed, the two dominant factors producing purple, the absence of the first producing green color, that of the second pink color, and the absence of both dominant factors resulting in the production of white fruits. It must be remembered that in the same cross, Owen (**9**) had obtained results for plant color which agree with the 9:7 ratio.

Bayla (**1**) gave results of a cross between a Purplish Native Elongated × New York Improved. From his work would seem that direct and reciprocal crosses do not give similar F_1 progenies. His study of the F_2 generation is very incomplete; he speaks about the F_2 hybrid, but no attempt is made at the study of the inheritance of color or any other character. Segregation is not studied in this generation.

In general, the data secured by the early investigators were insufficient for a complete analysis of the inheritance of color in the eggplant. The best data seem to be those given by Bailey and Munson (**3**) who were the only ones to make use of the backcross method. Summarizing these investigations it may be said that data have been offered suggesting a 9:7 ratio for plant color and 9:7, 9:3:3:1 and 3:1 ratio for fruit color and a 3:1 ratio for color of flesh.

It is the purpose of this paper to present the results of our studies on the inheritance of color of plant, fruit, and corolla, and the red-striped character of the anthers. In this connection purple color of plant has been studied as against green color, purple or violet corolla against white corolla, striped against non-striped anthers, purple fruit color in contrast to green or white and green color against white.

MATERIALS USED

The most important characters of the native eggplants used in these studies are given in table I. (See half-tone plates.)

It should be noted that the anther sacs burst as follows: in the varieties Fajardo, White Pompadour and Long Purple K, just before expansion of the corolla; in Camuy, Black Beauty, University and Green, during or after the corolla opens.

TABLE I. SHOWING THE SALIENT CHARACTERS OF THE EGGPLANT VARIETIES USED IN THIS PAPER

Variety	Plant Color		Fruit color	Corolla color	Anthers	
	Seedling stage	Adult plant			Striped	Non-sptriped
Fajardo	Green	Light Purple	Green purple striped	Violaceous		X
Camuy	Dark purple	Dark purple	Red to violaceous	Deep violaceous	X	
White Pompadour	Green or light purple	Light Purple	White purple striped	Violaceous		X
University	Purple	Purple	Pink	Violaceous	X	
Green	Green	Green	Green	White		X
Black Beauty	Light Purple	Light Purple	Purple	Violaceous	X	

The first planting of some of the varieties was made in the fall of 1926 and some crosses made the succeeding winter of 1926–27. Only a few of the crosses were made that season because not all of the varieties had been secured. Gradually additions were made to the collection and new crosses made. The first generation of the 1926–27 crosses was grown in the summer of 1927, and F_2 and back-cross generations planted in the fall of that same year, and data gathered early in 1928. When possible two generations were grown in the same year.

Emasculations were made as short a time before the bursting of the anthers as possible, which was the day previous to the opening of the corolla in all varieties except Fajardo, Long Purple K and White Pompadour where it was necessary to emasculate two days in advance of corolla opening. Pollinations were made as soon as the corollas were expanded. In the removal of the anthers and in the pollinating operations, the flowers were disturbed as little as possible to avoid unnecessary injury and consequent blasting of the fruits. They were properly bagged and tagged. The bags were removed after the young fruit had set, usually five or six days after pollination. All selfing was made by covering up the blossoms with glassine bags before expansion of the corolla.

The fruits were gathered when there was evidence of the yellow coloration on them and seed was cleaned immediately, dried in the shade and stored in mason jars in which a beaker of calcium chloride had been placed. There is little difficulty with the viability of the seed under such storage conditions.

The seed were sown in ordinary greenhouse flats from which 2–to 3–week–old plants were transplanted to other plots, allowing 12 to 16 square inches of soil per plant. The plots were carefully labeled to avoid any possible errors. With a reasonable amount of care the loss from transplanting was negligible.

It was soon found that plant color could be determined at the time when the seedlings were transplanted. The seedlings of the White Pompadour and the Fajardo do not develop any purple color before the second week and those of the Green variety are pure green from the beginning. In seedlings of the Black Beauty, color was evident after the first week and in those of Camuy and University it appears very early. Thus, in crosses in which any of the first three was involved with any of the remaining varieties, the seedlings were classed in two groups as colored and colorless (green). (See color plate III).

The sorting of seedlings presents no difficulty when the cross is between Green and any variety with purple seedlings, but when Green is crossed with either Fajardo or White Pompadour some difficulty is experienced making it necessary, with certain individuals, to make the final classification when the plants are transferred to the field. In the large seedlings (5 to 6 pairs of leaves) the purple color begins to appear in spots on the stem; but usually first on the main veins at the base of the leaf blade or on the petiole. In crosses between Fajardo or White Pompadour and any of the colored varieties the sorting out must be done early before any coloration shows in the recessive seedlings; if one waits too long they will be indistinguishable from the dominant ones.

The varieties given in the order of intensity of color of seedlings is as follows: Camuy, University, Black Beauty, White Pompadour and Fajardo.

If counts for plant color made in the seedbed on any given cross were confirmed by later field observations, duplicate crosses were carried only through the seedbed and there discarded.

Plantings in the field were made in rows three and one-half feet apart. Each row was numbered consecutively and the serial number kept season after season, starting with the second generation in 1927–28. A record was kept of each individual plant throughout the entire investigation making reference to row number and plant number. In this way it was very easy to trace back the history of any one of the many thousand seedlings grown in later generations.

Our data secured from F_2's and backcrosses are given below.

PLANT COLOR

Under plant color will be presented the study of the inheritance of the purple color in the different varieties. Since it was desirable to know whether the variations in color in the several varieties were really different, most of the varieties were tested with Green where the color remains constant throughout the entire life of the plant and with Fajardo where the green color changes to light purple during the seedling stage.

Table II shows the data on plant color in the various crosses. Observed numbers have been calculated on the basis of a 3 : 1 ratio and are also given in table II. Likewise, deviations from the observed numbers and probable errors, are also given.

In every case purple color was dominant over the green of either Fajardo or Green; the F_1 plants in all the crosses were purple.

The different shades of purple found in Camuy, Black Beauty and University reacted similarly toward Green. A second green found in Fajardo when crossed with University purple gave results similar to those secured in crosses of Green with purple varieties. It should be remembered that the Fajardo green is in reality a purple which does not appear until two or three weeks after the seedlings emerge.

TABLE II. SHOWING PLANT COLOR DATA ON F_2 AND BACKCROSS OF THE VARIOS CROSSES.

Progeny		Observed		Calculated	Deviation	P. E.	D/P. E.
		n	ratio				
1—Ca x Gr	Purple	885	2.94:1	889.50	4.5	±10.06	0.447
	Green	301		296.50			
2—Gr x Ca	Purple	1592	3.19:1	1580.25	11.75	±13.4	0.87
	Green	515		526.75			
3—(Ca x Gr) x Gr	Purple	149	1.09:1	143	6.0	±5.70	1.05
	Green	137		143			
4—Gr x BB	Purple	2404	2.80:1	2446.50	42.5	±16.65	2.55
	Green	858		815.50			
5—BB x Gr	Purple	442	2.73:1	453	11.0	±7.17	1.39
	Green	162		151			
6—(Gr x BB) x Gr	Purple	121	1.15:1	113	8.0	±5.07	1.58
	Green	105		113			
7—(BB x Gr) x Gr	Purple	169	1.17:1	157	12.0	±5.98	2.0
	Green	145		157			
8—Univ. x F	Purple	106	3.42:1	102.75	3.25	±3.42	0.95
	Green-striped	31		34.25			
9—F x Univ	Purple	213	3.28:1	208.50	4.50	±4.87	0.92
	Green-striped	65		69.50			
10—Univ. x Gr	Purple	152	4:1	142.50	9.50	±4.03	2.36
	Green	38		47.50			
11—Gr x Univ	Purple	191	2.85:1	193.50	2.50	±4.69	0.53
	Green	67		64.50			
12—(Univ. x Gr) x Gr	Purple	50	0.93:1	52.00	2.0	±3.44	0.58
	Green	54		52.00			

It can be generally said that observations agree fairly well with expectations on the basis of a 3:1 ratio of purple to green color of the variety Green (progenies 1–7 and 10–12). In every case the deviation is less than three times the probable error and, therefore, should be considered insignificant and can be attributed to random sampling. The green of Fajardo reacted in a similar way toward purple (progenies 8 and 9).

No progenies of backcrosses of Univ. $\times$ F have been produced. The first attempt was frustrated by damping-off of the seedlings of the only two progenies that germinated; a second attempt last summer was unsuccessful because of the very few seedlings that germinated. Consequently the evidence offered for a 3:1 ratio of purple to this green is based only on F_2 progenies.

It is clear that the different shades of purple found in the varieties Camuy, Black Beauty and University react similarly toward Green. A second green (Fajardo) when crossed with University, gave results similar to those secured in crosses of Green with purple varieties.

The assumption of one unit factor pair *Pr pr* for plant color will explain satisfactorily the results obtained.

FRUIT, ANTHER AND COROLLA COLOR

The study of inheritance of fruit color has involved the behavior of purple, red, pink, green purple striped and white purple striped. In corolla color we have been concerned with violet, purple and white and in stamen color we have dealt with red striped and non-striped anthers. In the preceding pages the data on plant color has been presented for four crosses. Our observations in those crosses have shown that green color of fruit is always associated with green plant color and purple, red and pink with purple color of plants. In the case of color of corolla it was found that white corolla was always associated with green color of plant in all the crosses. The non-striped character of the anthers always indicated recessiveness of fruit or plant color. Thus, in cases of crosses with Fajardo where corolla is colored and fruit is green, the recessive plants (green) always bore green fruit and non-striped anthers. In crosses with Green as a parent the green plants always bore green fruit, white corolla and non-striped anthers.

Therefore, the data and conclusions used in the analysis of plant color, will be the same for these characters.

FRUIT COLOR

In the crosses *Ca* × *Gr* (red × green), BB × Gr (purple × green) and Univ. × Gr (pink × green) a 3:1 ratio was found for plant color and since green fruit color was associated with green plant color the same ratio must apply to fruit color in these crosses.

In the cross Univ. × F (pink × green purple striped) a similar relation was found; all the plants sorted in seedbed as green bore green purple striped fruit.

Crosses between Black Beauty and Fajardo were made twice, but the F_2 and backcross data were not sufficient to arrive at proper conclusions as to ratio of inheritance. They proved, however, absolute dominance of purple over green fruit color.

In order to determine the relation of purple and green purple striped to white purple striped, Black Beauty (purple) and Fajardo (green purple striped) were crossed with White Pompadour (white purple-striped). Part of the progenies of the first cross was lost but dominance of purple was proved.

The results of the last cross appear in the following table.

TABLE III. FRUIT COLOR.

Progeny		Observed		Calculated	Deviation	P. E.	D/P. E.
		n	ratio				
13—Wh. P x F.....	Green.....	116	.....4.1	108.75	7.25	±3.52	2.05
	White.....	29	.....	36.25	.....	.....	...
14—F. x Wh. P.....	Green.....	120	3.44:1	126.75	6.75	±3.79	1.78
	White.....	49	.....	42.25	.....	.....	...
15—(F. x Wh. P.) x Wh. P.	Green.....	127	1.1:1	134	7.00	±5.52	1.27
	White.....	141	.....	134	.....	.....	.....

The evidence of F_2 data in the above table supports the assumption of a 3:1 ratio of green purple striped to white purple striped fruit. The backcross data furnish additional confirmation of expected results.

Summarizing the observations on fruit color it may be concluded that the red, pink and purples are dominant over green, green purple striped and white purple striped, but green purple striped was dominant over white purple striped. A 3:1 ratio was obtained with purple, red and pink in relation to green; a similar ratio between white purple striped and green purple striped. Therefore, one unit character produces color of fruit. It may be represented by *Cc*.

It should be remembered in closing, that certain unexplained observations were made in some of the F_2 progenies. In the F_2 of Univ. × F, five plants with white purple striped fruits were found

and classed with green for the purpose of the relation of pink to green. When perpetuated they have been found to breed true; i. e. the fruit is always white purple striped. In every other respect they are like Fajardo (green fruited) plants. Both University and Fajardo are true breeding varieties and therefore the appearance of these white purple striped fruit-bearing plants has been a matter of much interest to us during the whole time this work has been in progress. Things appeared still more complicated when two plants with these white purple striped fruits were discovered in the cross F × Univ.

This phenomenon is, to our mind, of much interest since it may throw some light on the true nature of the variety Fajardo which, as reported to us, arose in a graft of a white eggplant on *Solanum torvum*. The only difference between the new puzzling individuals and Fajardo individuals lies in the color of fruit; color of plant, corolla, and anthers, and shape of fruit are like in the Fajardo. In no case was an individual with white fruits obtained in any of many progenies of selfed Fajardo fruits.

The writer would make further studies with these interesting whites if it should be possible in the future.

It should be noted, in passing, that the observations of other writers in this respect are of interest. Owen (**8**) in 1912, for instance, in the F_2 of a cross where white and purple color were involved found greenish white fruited plants, and Halsted (**4**) in the same cross obtained greens again in a proportion of 3 : 1 toward the whites and even pink-colored fruits. The pink color in Halsted's may be explained as a dilution of the purple in the Dwarf Purple parent.

COLOR OF COROLLA

In these studies purple or violet (colored) corolla has been contrasted to white (non-colored).

In the direct and reciprocal crosses Ca × Gr, BB × Gr and Univ. × Gr it was found in the F_2 and backcross progenies that white corolla was always associated with green color of plant and fruit. Consequently the same general conclusions in the genetical analysis can be drawn for color of corolla as for plant and fruit color, namely that a 3 : 1 relation exists between color and no color and that colored corolla is due to one unit factor which may be represented by C_1 and white color by its absence and represented by C_1.

STRIPING AND NON-STRIPING OF ANTHERS

Striped anthers occur in the parents Black Beauty, University, Camuy and non-striped anthers in White Pompadour, Fajardo and Green.

In the crosses Ca × Gr, BB × Gr, Univ. × Gr. and Univ. × F, the absence of the stripes on the anthers was evident in the plants with the green fruits and in the first three of these crosses it was associated not only with green color of fruits but also with green plants and white corollas. In the cross Wh. P. × F where both parents had non-striped anthers, the F_1, F_2 and backcross progenies had all non-striped anthers. Hence, the same conclusions will hold for striping of anthers as for plant, fruit and corolla color. A unit factor will be assumed and represented as *St* with its recessive allelomorph *st*.

SUMMARY AND CONCLUSIONS

(1) Inheritance studies on the color in the eggplants have been made by various investigators but the first one to attempt an analysis was Halsted (**5**) who reported a 3 : 1 ratio of green to white color of flesh and a similar ratio of purple to colorless skin; also a 9 : 3 : 3 : 1 ratio of purple, green, pink, and white fruit. Several workers have pointed out the dominance of purple color over white in fruits. Bayla (**1**) apparently regarded F_1 generations of reciprocal crosses as dissimilar.

(2) The methods employed in the various crosses are given.

(3) Seedlings in some of the crosses could be classified according to their color during the very early stages. Plants of the Green variety remain green throughout the entire life cycle, those of Fajardo and White Pompadour are green during the first two or three weeks only and then turn light purple; while those of Camuy, Black Beauty and University are purple from the very beginning.

(4) Intense purple color of Camuy is inherited in a 3 : 1 ratio to Green. The same ratio exists between the green of Green and the purple of University and Black Beauty. The University purple is inherited in the same ratio in respect to Fajardo green purple striped. For all these a unit factor *Pr pr* is assumed.

(5) Green color of fruit in the crosses studied is always associated with green plant color; and purple, red and pink with purple color of plant. White corolla is always associated with green color of plant; striped anthers with a recessive factor for fruit or plant color.

(6) Red, purple and pink color of fruit is dominant over green and inherited in a 3 : 1 ratio. Likewise green purple striped is domi-

nant over white purple striped and is inherited in a 3 : 1 ratio. Purple was proved to be also dominant over white purple striped. Green purple striped acts as a recessive in respect to pink or purple, but as a dominant in respect to white purple striped.

(7) Violet or purple corolla is dominant over white corolla. They stand in a 3 : 1 ratio in the F_2 generation.

(8) Striping of anthers is dominant over non-striping and is inherited in a 3 : 1 ratio.

(9) A unit factor appears to exist for each of the characters; color of plant, color of fruit, color of corolla and striping of anthers. The following allelomorphic pairs of factors are assumed: plant color *Pr pr*, fruit color *Cc*, corolla color C_1c_1, and striped character of anthers *St st*. A single factor might be assumed as affecting all the characters here involved.

(10) There may be complete linkage between these characters: White corolla and non-striped anthers always stand for green fruit, and green plant (all recessive characters). On the other hand striped anthers always go with bright-colored fruit and with purple plants.

(11) The composition of a green plant with white corolla, green fruit and non-striped anthers may be represented as prpr cc C_1 c_1 ststst, or as prpr, cc, etc.

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CORNELL UNIVERSITY,
Ithaca, N. Y.

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Explanation of Plates

Plate III. Plant Color. Parents Camuy (1), and Green (2). Fig. 3 is the F_1 of the cross Camuy $\times$ Green. Figs. 4–7, F_2 generation seedlings, 3:1 ratio of purples to green.

Plate IV. Corolla and anther characters, Fig. 1, corolla of Camuy, anthers striped; fig. 2, Fajardo, non-striped anthers; fig. 3, white Pampadour, non-striped anthers; fig. 4, University, striped anthers; and fig. 5, white corolla of Green, anthers non-striped.

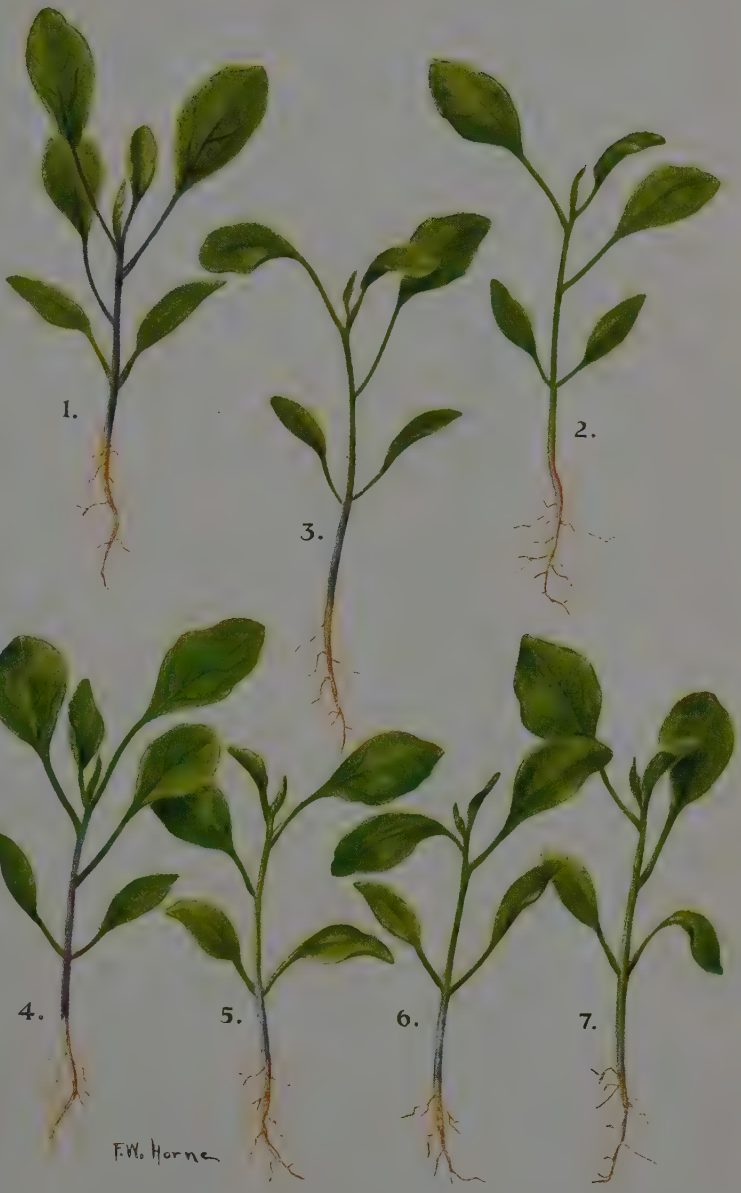
Plate V.—Black beauty eggplant.

Plate VI.—Fajardo eggplant.

Plate VII.—University eggplant.

Plate VIII.—Left: Green eggplant,
Right: White pompadour eggplant.

PLATE III.



1.

2.

3.

4.

F.W. Horne

5.

PLATE V.

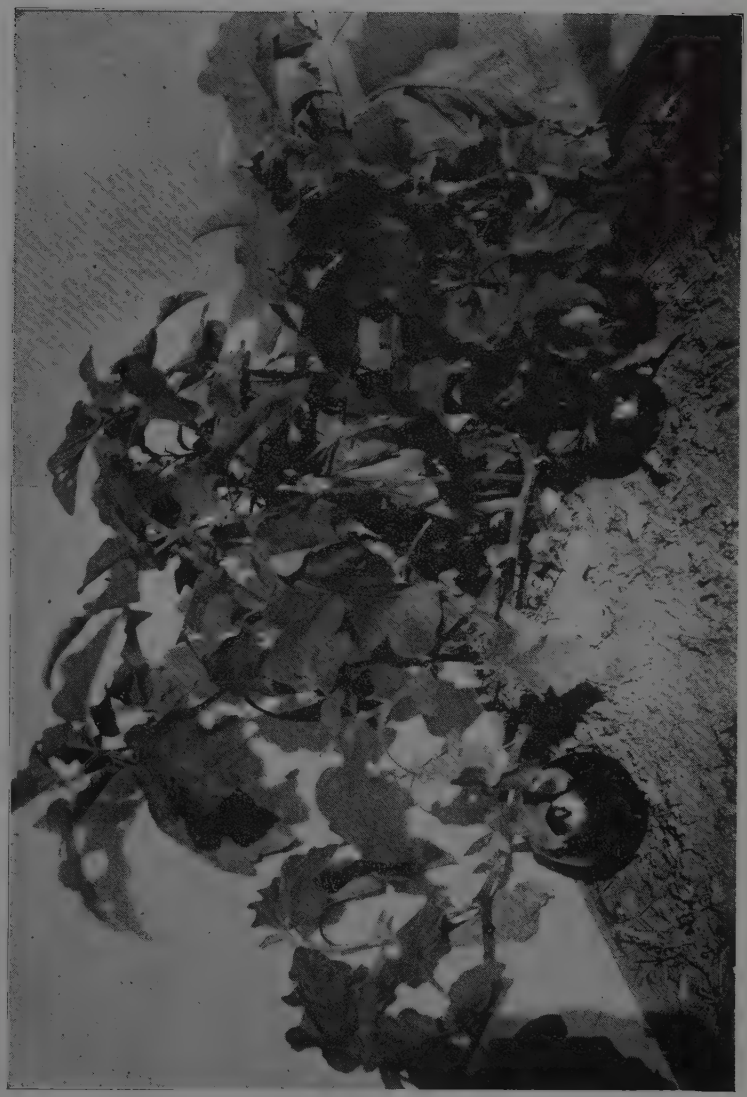


PLATE VI.

PLATE VII.

PLATE VIII.

A NEW SPHAERODACTYL FROM PORTO RICO

CHAPMAN GRANT, Major, United States Army

Sphaerodactylus gaigeae sp. nov.

Type No. 3358, male, Chapman Grant Collection, 7 Sept., 1931, mountains near Yabucoa, Porto Rico; collector, Chapman Grant.

Diagnosis: A *Sphaerodactylus* of medium size, 45 mm., very dark above, almost black; usually dark beneath. Throat dark with white spots, but this unique character fades in alcohol; habitus slim; scapular pattern wanting or reduced to light dots; head pattern in shape of "chevrons". No sexual dichromatism. Snout and throat strongly keeled.

Habitat: Mountains between Maunabo and Yabucoa, Porto Rico. Found under vegetable trash in moist situations.

Proportions: Slender; medium size, 45 mm. adult average.

Squamation: Upper side; scales across snout just in front of eyes, 12. This line to snout, 5. Scales all keeled including those bordering rostral. Lower side; Larger scales bordering mental, followed by smaller scales which increase in size at neck. All strongly keeled including chest. Belly scales smooth. Male escutcheon large.

Color and markings: No sexual dichromatism. Above; very dark brown, almost black. Head pattern a black "chevron", apex pointed forward at occiput outlined by a narrow light margin. Head pattern is unique among Porto Rican and adjacent island forms. Scapular pattern wanting or reduced to two light dots. Occasionally a sacral pattern of a pair of light longitudinal lines outlining three or four black scallops beginning at sacrum and extending onto tail. Below; chin black with light dots. This is a unique marking, but fades in alcohol. Belly marbled with dark, occasionally all gray. Also fades in alcohol. Underside of tail usually deep orange, occasionally brown. The orange fades in alcohol.

Remarks: Specimens taken, 22. This species is found associated with S. *grandisquamis*. When capturing these specimens I thought I was taking immature *S. klauberi*. This is the only "black" smooth bellied species known to occur on Porto Rico or the adjacent islands. It is much the blackest form, *S. klauberi* being a dark walnut. Named in honor of Helen T. Gaige.

CHART FOR DETERMINING THE SPHAERODACTYLS OF THE PORTO RICO REGION

CHAPMAN GRANT, Major, United States Army

It is hoped that the reader has seen the paper by the same author describing five new *Sphaerodactyls* and reestablishing another in the July number of this Journal as this chart is for the ready determination of these and the new species described in this number of the Journal. Altogether there are eight species now known from this region.

I find that a key has an objectionable feature because a decision must frequently be made on a matter of opinion or definition. A reader unfamiliar with a group may be led astray by a wrong choice while using a key. In the present chart any specimen may be referred to any of the thirteen columns. There is no necessity for starting over as is necessary with a key, because if one column leads to an impasse with a certain specimen, the student may ignore that character and run down one of the other columns.

In making an identification it is advisable first to determine the sex of the specimen. It will be noted that three of the eight species have sexual dichromatism. Sex determination immediately narrows the field.

Sex determination is easy in this genus. Examine the belly scales with a hand lenz. The male has a chevron shaped patch of noticeably flat or slightly concaved and usually lighter colored scales anterior to the vent. The branches of the chevron extend onto the hind legs. The scales of this part of the female are not differentiated. See Plate XX. July number of this Journal.

Use of the Chart. Explanation of Terms.

In Column 6, the "cross" on the head of *S. monensis* is more or less a matter of opinion. I will gladly adopt a more comprehensive term. The advantage of the term "cross" is that there are various types of crosses. There are also various designs on the head of *S. monensis.*

"The target" is an oval occipital spot encircled by an oval ring, usually of the same color.

Columns 7 and 8. The species of this group have a dark line or the vestiges of one, beginning at the eye and extending backwards for various distances according to the species. This line is bordered

above by a lighter line, also extending variously according to the species.

Column 9. The "chin" bears a pattern that is quite specific in certain forms. By "chin" is meant the area from the mental to a line joining the bulbs of the lower jaw. Some might call it the "throat".

Column 10. The "scapular pattern" is a feature of this genus. It is best shown in *S. grandisquamis*. In this species it usually consists of a black blotch across the shoulders, outlined by white and bearing two white dots. The resemblance to a mask is striking. "Spectacle" is suggested by Dr. Barbour for the scapular pattern when it tends to change from a mask to two little tangent targets.

Column 11. The "sacral pattern" is second only to the scapular pattern in this genus. Usually it is most conspicuous at the region of the sacrum, but is frequently repeated several times along the tail. Generally it is formed by a continuation or reappearance of the ocular white line and the outermost dorsal dark line or line of dots which is intensified at this point. The form and degree of this pattern is specific.

Columns 9, 12 and 13. Keels: It is very difficult to determine whether or not certain scales are keeled in these species. It is necessary to let the specimen become slightly dry and to scan it with a hand lenz in a mild light that comes from the side. A bright light or a direct light, moisture or too high magnification make the keels almost invisible.

Notes to Sphaerodactyl Chart.

1. Fades in alcohol.

2. The Culebra form only is covered in this chart. The form from Vieques is covered by these notes where it differs from the Culebra form and is referred to by the letter "V". The Culebra form is referred to by the letter "C".

3. Red head. The C has a plain red head above in 22 per cent of the males, with no intermediate forms with the speckle head males. The V has a larger per cent of red head males and the red continues underneath the head as red or orange. Some have a dark occipital spot on the red head and some have spotted or marbled chins, whereas C invariably has a white chin and no occipital spot.

4. Brown. The V is much darker brown than C.

5. V males, not the red heads, have regular "target" or mottled head.

6. See Note 3.

7. In V this line is much darker, nearly black.

(1)	(2) Sex Dichromatism	(3) Habitat	(4) Av. Adult Size	(5) Gen'l Color Above	Head Pattern		Dark Eye Line		Light Eye Line		Chin		Scapular Pattern		Sacral Pattern		J							
																	Collar	Post	Lip	Keeled	Dorsals regular	Dorsals irregular	Dorsals angular	No. of rows between
endi,	—	Cape San Juan, P. R.			—	—	brown, same as	does not	light, more		clear		—											
	—	Cabo Rojo, region, P. R.	40	brown	—	—	brown, same as head,	seldom behind	—	—	clear	first row faint		outlined in										
		Cabo Rojo, region, P. R.		black and	—	vived parallel	black, vivid	to hind	white,	to hind			—	parallel lines	—	vivid parallel lin								
						row	none or	if present	none or	if present				per mel "mark-	—									
	—	P. R.			—	—									—									
	—						markings																	
		Porto Rico			rarely	weak	lighter brown than none or	pattern	more prom none or		spotted	mental												
	female	Culebra, 2 and		4	strong	"target"	same dark brown 7 as head markings	to shoulder	wider than dark line 9	pattern or to tail,	black and	except	strong 12	small "mask"	unusual 13	blotch, light strip behind 14								
	male	Vieques,	50	gray	weak	specks 5	usually black lots on head 8	to ear	indistinct light brown	to ear	speckled 10	bordering mental weak or	very small or	very small "mask	—	—	+	—	—					
	male			brown redhead 3	—	— 6	—	—	—	—	white 11				—	—								
	—	mountains of Yabucoa, P. R.	45	"black"	weak	"chevron"	black, hardly discernible	to ear	lighter, hardly discernible	to ear	black 1 with white	all strong	faint or wanting	two light dots	hardly discernible	lighter lines outlining scallops	+	+	—	an keeled	—	—	—	22

8. V males have the dark eye line a light brown instead of "black".

9. White in V.

10. In V, gray or black and white speckled or striped.

11. In V, orange or white or gray or mottled. The orange fades in alcohol.

12. In V, reduced or wanting.

13. In V, usual.

14. In V, same pattern, but repeated several times onto tail.

THE HERPETOLOGY OF VIEQUES ISLAND

CHAPMAN GRANT, Major, United States Army

Dr. Leonard Stejneger, 1904, in "The Herpetology of Porto Rico" lists eleven reptiles and amphibians from Vieques, as follows:

Species	Latest Record	
1. *Leptodactylus albilabris*	Stejneger	1900
2. *Eleutherodactylus antillensis*	Stejneger	1900
3. *Sphaerodactylus grandisquamis*	Stejneger	1900
4. *Anolis cuvieri*	Reinhardt & Luetken	1862
5. *Anolis cristatellus*	Stejneger	1900
6. *Anolis stratulus*	C. W. Richmond	1900
7. *Anolis pulchellus* "?"	Reinhardt & Luetken	1862
8. *Ameiva exsul*	Reinhardt & Luetken	1863
9. *Mabuya sloanii*	Riise	1863
10. *Typhlops jamaicensis* "?"	Reinhardt & Luetken "Virgin Islands"	1863
11. *Alsophis antillensis*	Boulenger	1894

He lists *Anolis pulchellus* and *Typhlops* jamaicensis with a "?". The latter is recorded from the "Virgin Islands". It is clear that he expected both species to be on Vieques, but had no proof in regard to *Typhlops.*

Karl P. Schmidt, 1928, in the Scientific Survey of Porto Rico and the Virgin Islands lists 10 of the same reptiles and amphibians from Vieques. He apparently took only *A. cristatellus, pullchellus* and *stratulus,* counting on the authority of Stejneger for the remainder. He leaves out *Typhlops* which Stejneger included only on probability.

The writer made a trip to the Island in 1931, where, with the assistance and hospitality of Mr. S. C. McCall, 6 species were added to the fauna and 1 removed, bringing, the total to 15.

I found the two *Salentia* very numerous and noisy.

The first new record, *Hemidactylus mabouia,* was found around old stone buildings at night. It is discussed elsewhere in this issue. *Sphaerodactylus townsendi* and *S. roosevelti* occur on the extreme eastern dry tip of the Island. Elsewhere *Sphaerodactylus danforthi* or a closely allied form occurs under trash or palm leaves. This is a two-color-phase-male form. On Culebra there were no intermediates between the speckled head and red-head males, but on Vieques all integrades were found. The form from Vieques shows constant

minor differences from *Sphaerodactylus danforthi*, which I believe to be of specific or sub-specific value. They are discussed in another paper. Searching on the extreme dry eastern tip of the Island, in the almost impenetrable brush, I turned over the remains of a deserted termite nest which had fallen to the ground. I saw a large, coarsely scaled *Sphaerodactylus* and grabbed. To my delight, I felt the wriggle in my hand, but upon examination, I found only a part of the tail. A diligent search failed to recover the important part of the specimen. The glimpse I had made me think it was *S. roosevelti*. I turned over a rock nearby and found the hatched shells of large *Sphaerodactylus* eggs and one partly incubated egg. A month later, Oct. 28, 1931, the egg hatched into what might well be a female *S. roosevelti*. I made color notes as follows: Bright yellow, brightest at tail. A light yellow stripe starts between eyes and extends to tip of tail, bordered on head by slightly darker edges. Dark greenish yellow stripe, width of eye, extends nearly to end of tail, but at scapular region this line is jet black with a tiny white dot in the center. At sacral region, this line is little darker. Behind eye a light yellow line which is interrupted at ear and recommences behind ear runs well onto the tail. A narrow dark line below the latter. Flanks bright yellow. Tiny tip of tail white. A beautiful creature. 32 mm. long when hatched. Egg 9×7 mm. The following day the colors began to fade and the day thereafter the skin loosened up preparatory to shedding. The adult *S. roosevelti* does not have any yellow, but it is quite possible that the young may have it. The classification of the above specimen is tentative until young of *S. roosevelti* are taken at the southwest corner of Porto Rico, whence I described the species in this Journal, Vol. XV No. 3, page 203 and plate.

Anolis cristatellus is numerous. The fan has a broader orange band than the Porto Rico form but does not approach the color or width of the Culebra form.[1] I found the high tail fin in about the same proportion as on Porto Rico. I searched for *Anolis stratulus* but failed to find any. *Anolis pulchellus* was not very abundant. I looked for a variant on the dry eastern end of the Island but neither was to be found. I did not find a native who had ever seen *Anolis cuvieri*.

Ameiva exsul fairly swarms on outlying keys. Schmidt thought it extinct on the main Island where the mongoose abounds, but I saw a few *Ameivas* on the eastern extremity. I believe it is too dry there for the mongoose.

Mabuya was not seen or known to the natives.

I have one specimen of *Typhlops* sp. collected by Mr. S. C. Mc Call.

Alsophis antillensis is probably nearly extinct except on outlying keys or possibly the eastern tip of the Island. Some natives report having seen a few snakes within the past several years.

The natives speak of the "culebrón", *Epicrates* as occurring on the off shore keys.

I saw a pet *Pseudemys* in a cistern. The natives claim they are numerous in the lagoons and are sold on the streets for fifteen cents apiece.

An old citizen of repute says that after several of the hurricanes, large agglomerations of broken branches and trees have floated over from Porto Rico and that *Pseudemys* has been found in such situations. Such a phenomenon would require an unusual wind of sufficient duration and intensity to overcome the current running between the two islands. Personally, I believe that *Pseudemys* and *Epicrates* are the only forms which might survive such an experience.

The species that I strike from the list is Stejneger's *S. grandisquamis* or *S. macrolepis* which Schmidt later confused with *S. grandisquamis.* See page 43 of this issue for discussion.

The herpetological list of Vieques I believe comprises the following:

Species	Latest Record	
1. *Leptodactylus albilabris*	Grant	1931
2. *Eleutherodactylus antillensis*	Grant	1931
3. *Hemidactylus mabouia* "*"	Grant	1931
4. *Sphaerodactylus townsendi* "*"	Grant	1931
5. *Sphaerodactylus danforthi* "*"	Grant	1931
6. *Sphaerodactylus roosevelti* "*"	Grant	1931
7. *Anolis cristatellus*	Grant	1931
8. *Anolis stratulus* "?"	Schmidt	1928
9. *Anolis pulchellus*	Grant	1931
10. *Anolis cuvieri* "?"	Reinhardt & Luetken	1862
11. *Ameiva exsul*	Grant	1931
12. *Mabuya sloanii* "?"	Riise	1863
13. *Typhlops, sp.* "*"	Grant	1931
14. *Alsophis antillensis* "?"	Boulenger	1894
15. *Pseudemys stejnegeri* "*"	Grant	1931

NOTE: 1. See p. 220 Vol. XV No. 3 of this Journal.

The "?" denotes species not collected by the writer.

The "*" denotes species added by the writer.

BUFO LEMUR, A RARE PORTO RICAN TOAD

CHAPMAN GRANT, Major, United States Army

Bufo lemur was known to the natives of Porto Rico as "sapo concho" because of its bony or shell-like head. At the time of Dr. Stejneger's visit, the name had been transferred to *Leptodactylus albilabris*. At present *Bufo marinus* bears the name for which it does not qualify. *Bufo lemur* seems to have always been scarce, or its hiding places are not yet understood.

Cope named the form *Peltaphryne lemur* in 1868. Peters called it *Peltaphryne gutturosus* in 1876 and Gundlach, *Bufo gutturosus* in 1881. Stejneger straightened things out in 1902 with *Bufo lemur*.

The only records that I can find of its capture are:

Dr. Stahl secured six specimens in forty years of collecting in the 18—'s. Stejneger captured five specimens near Arecibo in 1900. Schmidt took five specimens at Coamo Springs in 1919, thereby greatly enlarging the known range of the species. It had been known only from the north side of the Island. Dr. J. García Díaz secured one at Arecibo in 1925. Mrs. D. J. Haydon, of the University of Porto Rico secured two from Barceloneta in 1928. Danforth collected eight at Coamo Springs in 1929. I captured the present specimen a mile north of Coamo Springs in 1931. A total of only 28 known specimens of this species taken in sixty-three years.

Noticeable about this toad is its limber back bone. It can turn about so that in handling it, it feels more like a warty salamander than a toad. Its mouth is not terminal as in ordinary toads but underneath like a shark's. When captured, it was sooty black all over. Soon it turned to a black and white marbled symmetrical pattern, too complicated to try to describe. The hour glass pattern on the back mentioned by Stejneger is present. The eyes of this specimen are decidedly coppery instead of brassy as in the specimen that Stejneger describes.

Dropped into a tub of water it swims well on and below the surface. Kept in a bottle it ate two katydids, tiger beetle, *Anolis cristatellus* 4" long and cockroaches.

This toad is closely allied to *B. empusus* (Cope), of Cuba and *B. gutturosus* Latreille of Hispaniola, both of which are relatively common. *Bufo turpis* Barbour of Virgin Gorda was known only from the type specimen until Dr. Stuart Danforth of the University of Porto Rico at Mayagüez took eight specimens last year. He found them under the bark of dead mangrove trees.

EXPLANATION OF PLATE IX

Bufo lemur front view and side view. This is probably the only picture ever taken of this species alive. Photos by Capt. F. V. Edgerton, U.S.A.

PLATE IX.

SPHAERODACTYLUS GRANDISQUAMIS, A VALID SPECIES

CHAPMAN GRANT, Major, United States Army

Stejneger [1] described *Sphaerodactylus grandisquamis* in 1902 from a series of 47 specimens taken at Luquillo and near Ponce. He added 9 other specimens from Vieques under this name, altho noting a marked difference in coloration and pattern.

The selection of the name *grandisquamis* was not a happy one as it calls attention to a trivial and uncertain factor. Unfortunately Dr. Stejneger attributed the sexual dichromatism and markings which are so distinct in this species to individual variation. He did not have a sufficient series to make it apparent to him that this species is larger than *macrolepis,* nor that *grandisquamis* is the only species with a distinct white tail tip and a usually perfect scapular "mask".

In 1914 Barbour [2] says: "This species, [*grandisquamis*] which had hitherto been confounded with *Sphaerodactylus macrolepis* Gunther, the type locality of which was St. Thomas, has been shown by Stejneger to be perfectly distinct, yet to have close affinity with Gunther's species. Stejneger's species may easily be separated by its much larger dorsal scales. In its distribution it is confined to Porto Rico and Vieques".

In 1915 ? Fowler [3] accepts the species without question: "Three from Arecibo Road, Porto Rico, about the 70 km. post; these are similar to Dr. Stejneger's figure,[4] [this figure is of a female], except that the black scapular blotch has in each example two small pure white spots. Two specimens have the dark spots as more or less broken longitudinal bands, [probably females] though in the remaining example a more speckled appearance is seen and the spots are smaller." Undoubtedly this last is a male.

Again a series too small to make evident the interesting sexual dichromatism and markings of this form.

In 1917 Barbour [5] says: "*Sphaerodactylus macrolepis* Gunther. In the collection there are specimens from St. Thomas, Tortola, Virgin Gorda and Anegada. These have been compared with a large series in the M. C. Z. from St. Croix. All belong to the same species; the Anegada specimens are much paler, more ashy, than any of the others and the variation observable in this large number of individuals shows that *Sphaerodactylus grandisquamis* Stejneger,

from Porto Rico, distinguished by the larger size of the dorsal scales is really far from conspicuously distinct. The species may perhaps stand, however, since there is no doubt but that the average number of scales upon the dorsal area is slightly fewer."

We must begin to note that there are other things than scale counts which when constant, constitute a species.

In 1920, Schmidt[6] lumps the two species together. I have not seen his paper.

In 1921 Barbour[7] states: "I cannot, with this large material before me, find any stable character separating *macrolepis* from *grandisquamis*. Certainly in specimens of equal size the dorsal scales differ but very little in size. In the topotype of *macrolepis*, figured, they are actually larger than in the specimen of *grandisquamis*. . ."

Barbour's figures are of females of *S. macrolepis* fig. 2 and *S. grandisquamis* fig. 3. In his description of *macrolepis* he uses a Porto Rico specimen, i.e. *grandisquamis*. If we could only get away from scale counting and not let the trees obscure the forest.

In 1928, Schmidt[8] lumps *macrolepis, grandisquamis* and *monensis*. He shows cuts of a male and a female as "common types of pattern". He proves that by scale count the three species are one. No attention has been paid to color, size, pattern, sexual differences, proportions or habits, which differ and are constant in each of the three species.

In 1930, Barbour[9] does not list *monensis* or *grandisquamis*, allowing *macrolepis* to answer for the three.

In the July number of this Journal, I reestablished the validity of *monensis*. I had not seen specimens from St. Croix, so considered them identical with the Porto Rican form. This belief was engendered by the quotations at the beginning of this article. Upon collecting a small series from St. Croix, I immediately realized that the Porto Rico form was distinct, and therefore *grandisquamis* was valid. The close similarity between the forms from St. Croix, Culebra and Vieques would make my *danforthi* from Culebra and Vieques of only sub-specific value, if it were not for the fact that I found no red-head males on St. Croix and find no mention of this phase in the literature. A larger series from St. Croix may show the forms from St. Croix, Culebra and Vieques to be sub-specific inter se. My "Chart for Determining the Sphaerodactyls of the Porto Rican Region" in this issue still further brings out the differences between the species.

My opinions are based on fifteen months of constant work in the field where I have observed hundreds of specimens. I have hatched

out many eggs and observed the young. My study collection at this time contains 228 *grandisquamis* from Porto Rico and 157 *danforthi* from Culebra; 63 *danforthi* from Vieques and 11 *macrolepis* from St. Croix.

It is my conviction that the specific differences of the Sphaerodactyls of the Porto Rico region should be based on the characters shown in my "Chart" as well as on scale count.

A resume of the outstanding differences between the four species is not amiss here as *macrolepis* is not included in my "Chart". There are other constant differences between the St. Croix, Vieques and Culebra forms which are omitted here.

	White tail tip	Av. adult size	Sex dichromatism	Color above	Head pattern	Chin	Scarpular pattern	Red head males
grandisquamis	+	60	+	Brown	♀ weak ♂ rare	♀ clear ♂ spotted	♀ large "mask" ♂ small "mask"	—
macrolepis	—	50	+	♀ brown ♂ gray	Vivid	Black and White	♀ small "mask" ♂ very small "mask"	—
danforthi	—	50	+	♀ brown ♂ gray brown	♀ vivid ♂ rare	Blach & White red-head clear	♀ small "mask" ♂ very small "mask"	+
monensis	—	50	—	Gray	Weak	White	"spectacles"	—

NOTES

1. **Leonard Stejneger,** The Herpetology of Porto Rico, U.S.N.M. 1904, pp. 602–7.
2. **Thomas Barbour,** A Contribution to the Zoogeography of the West Indies with especial reference to Amphibians and Reptiles, Mus. C. Z. Vol. XLIV No. 2, March, 1914.
3. **Henry W. Fowler,** Some Amphibians and Reptiles from Porto Rico and the Virgin Islands. Acad. Sci. Phila. p. 7.
4. **Rep. U. S. Mus.,** 1902, p. 605, fig. 52.
5. **Thomas Barbour,** Notes on the Herpetology of the Virgin Islands. Pro. Biol. Soc. Wash. Vol. 30, p. 98.
6. **K. P. Schmidt,** Ann. N. Y. Acad. Sci. p. 184.
7. **Thomas Barbour,** Sphaerodactylus Mem. Mus. Comp. Zoo. Vol. XLVII, No. 3, pp. 253–5.
8. **K. P. Schmidt,** Scientific Survey of Porto Rico and the Virgin Islands. N. Y. Acad. Sci. Vol. X, pp. 70–4.
9. **Thomas Barbour,** A List of Antillean Reptiles and Amphibians, Zoologica, N.Y.Z.S., Vol. XI, No. 4, p. 83.

THE HERPETOLOGY OF CAJA DE MUERTOS ISLAND AND CARDONA KEY, PORTO RICO

CHAPMAN GRANT, Major, United States Army
and CORNELIUS ROOSEVELT

The interesting little Island of Caja de Muertos, Coffin Island, 8 miles off Ponce, Porto Rico, has been nearly ignored by herpetologists. It is not mentioned by Stejneger, 1904, in his "Herpetology of Porto Rico", or by Barbour, 1930, in his "A List of Antillean Reptiles and Amphibians". Schmidt, 1928, Vol. X, Part 1, "Scientific Survey of Porto Rico and the Virgin Islands" mentions *Anolis cristatellus, Ameiva wetmorei* and *Alsophis portoricensis* as the only forms known from the Island.

On July 26th, 1931, the joint writers visited the Island and secured the following 53 specimens, adding 3 species to the fauna, bringing the total to 6 species:

Anolis cristatellus, 21; very numerous and apparently not differing in habits or form from the mainland specimens.

Anolis pulchellus, 3; not abundant, but apparently not differing in form or coloring from the mainland specimens.

Ameiva exsul, 6; not abundant, seemingly the dorso-lateral stripes persist longer than in the mainland specimens.

Ameiva wetmorei eleanorae, 6; not abundant; described in this paper.

Sphaerodactylus townsendi, 17; not rare, differ slightly from the Vieques and Porto Rican specimens.

On August 20, 1931, we received a small collection comprising *Anolis pulchellus,* 3; *Sphaerodactylus townsendi,* 4; *Typhlops jamaicensis* sp. ?, 2; *Alsophis portoricensis,* 3; and *Phyllodactylus tuberculosus,* 1, adding 3 species to the fauna, bringing the total to 9 species.

On November 26, 1931, the senior writer again visited Caja de Muertos and captured 38 specimens:

Sphaerodactylus townsendi,	5;	*Ameiva wetmorei eleanorae,*	14;
Phyllodactylus tuberculosus,	1;	*Ameiva exsul,*	3;
Anolis pulchellus,	1;	*Typhlops jamaicensis, sp.?,*	2;
Anolis cristatellus,	11;	*Alsophis portoricensis*	1.

The *Alsophis* do not resemble the series of eight *A. portoricensis* in the Grant collection, but resemble the series of thirty *A. antillensis* in the same collection, in color and pattern but not in squamation.

The *Typhlops* appears to be distinct.

Barbour mentions *Phyllodactylus spatulatus Cope;* "Barbados collected years ago, about 1861, in fact, by Dr. Theodore Gill. I have no recent information as to its status". This is the nearest record of this genus to the present locality. The present find adds a genus to the Porto Rico fauna and a species to the Antilles.

On November 26, 1931, the senior writer visited Cardona Key, a tiny sand-coral islet bearing a light-house, off the harbor of Ponce. *Ameiva exsul* fairly swarms and *Anolis cristatellus* is numerous. Nine *Ameiva exsul* and three *Anolis cristatellus* were taken. *Exsul* exhibited a wide range of color and pattern, but no turquoise blue tails or red or salmon undersides were seen. Some specimens had light brown unmarked backs, others had two complete white lines below the dorso-lateral line along the sides, formed by the coalescence of white dots. *Critatellus* showed no markings and a plain olive fan.

Ameiva wetmorei eleanorae subsp. nov.

There are 135 specimens of *A. wetmorei* in the Grant collection from the neighborhood of Cabo Rojo, P. R. There is little variation in this series. The white stripes are narrow and there is a faint brown stripe between the mid-dorsal stripe and the continuation of the subocular white stripe. This brown stripe is the continuation of the subocular white stripe.

Type No. 2734, Grant Collection, July 26, 1931, Caja de Muertos Island, Porto Rico. Collectors. Roosevelt and Grant.

Diagnosis: Differs from *A. wetmorei* in having wider dorso-lateral white stripes. The supraocular white stripes usually stop at the base of neck instead of continuing on to tail as a brown stripe.

Habitat: Caja de Muertos Island, Porto Rico.

Proportions and squamation: As in *A. wetmorei.*

Color and pattern: The mid dorsal white line turns blue as it passes the sacrum. In the Muertos form this wide blue stripe includes an uneven, broken central black line from near the sacrum. In the Porto Rican form if the central black line occurs at all, it is much further down the tail. The supraocular white line usually stops at the neck in the Muertos form, leaving a jet black space between the middorsal white line and the continuation of the subocular white line. In the rare cases where this line continues in the Muertos form, it is merely as a faint white line. In the Porto Rican form, the supraocular white line turns brown at the shoulders and continues onto the tail. In the Muertos form the lowest white

line which runs from armpit to groin is as clear cut and distinct as those above it. In the Porto Rico form, the lowest white line is blurred or wider than the ones above it. The Muertos form has a much tidier clear cut pattern with more contrast.

WIDTH IN SCALES OF MIDDORSAL WHITE LINE AT:

	scapular		midbody		sacral	
	min	max	min	max	min	max
A. wetmorei eleanorae	2	3	3	3½	3½	5
A. wetmorei	1	2½	1½	3	2½	4

AVERAGES OF THE ABOVE:

	scapular	midbody	sacral
A. wetmorei eleanorae	2.5	3.2	4.1
A. wetmorei	1.9	2.2	3.3
difference	.6	1.0	.8

Remarks: Specimens taken 20. Named in honor of the junior writer's Mother, Eleanor Roosevelt.

The habits of this species are mentioned by the senior writer in "Copeia", July, 1931.

THE HEMIDACTYLS OF THE PORTO RICO REGION

CHAPMAN GRANT, Major, United States Army

Two species of *Hemidactylus* are known to occur in the West Indies, *H. mabouia* and *H. brookii.*

There has been some misunderstanding in the classification of the *Hemidactylus* of Porto Rico and the adjacent islands of St. Thomas, Vieques, etc. The following scientists have listed *Hemidactylus mabouia* (Moreau de Jonnes) as occurring on Porto Rico:

1868 Cope, Proc. Phila. Acad. p. 311;
1881 Gundlach, Anal. Soc. Espan. Hist. Nat., X. p. 308;
1887 Garman, Bull. Essex Inst., XIX p. 18;
1893 Boettger, Kat. Rept. Mus. Senckenberg, I, p. 28;
1904 Stejneger, Ann. Rept. U. S. N. M. p. 599;
1928 Schmidt, N. Y. Acad. Sci., X. p. 69;
1930 Barbour, N. Y. Zoo. Soc. XI. p. 82.

I accepted the above evidence unquestioningly until my large series showed that a mistake had been made.

I doubt whether *H. mabouia* ever occurred on Porto Rico. Both Stejneger and Schmidt admit not having taken it. Stejneger describes a Cuban specimen of *H. brookii* in ascribing Porto Rico as the range of *H. mabouia.* Later students may have followed his lead. I believe that earlier writers did not have sufficient material for a correct diagnosis and that at present the distinction between the species is little understood.

My collection contains thirty-four *H. mabouia* from Vieques and five from St. Thomas. I have seen only *H. brookii* on Porto Rico.

Hemidactylus brookii Gray is listed by Barbour as occurring in Hispaniola and West Africa. My collection contains 99 specimens taken at San Juan, Río Piedras, Humacao, Caguas, Ponce, Playa de Ponce and Mayagüez, all on the island of Porto Rico.

KEY TO THE SPECIES OF *Hemidactylus* IN THE PORTO RICO REGION

a 1. Six rows of spines around base of tail, dorsal pattern, four black "Vs", femoral pores of males not interrupted at midline. St. Thomas and Vieques.—*H. mabouia.*

a 2. Eight or ten rows of spines around base of tail; dorsal pattern brown, mottlings or four rings; femoral pores of males interrupted at midline. Porto Rico.—*H. brookii.*

A detailed description of both species follows. The characters which differ in the two species are italicized for comparison.

HEMIDACTYLUS BROOKII

Based on a series of 99 specimens.

Diagnosis: A gecko of moderate size, the basal half of each digit expanded and provided beneath with several pairs of lamellae and *one large* distal lamella, the distal half compressed, arising from within the tip of the expanded portion, curved, and provided with a claw at the tip; *eighteen* rows of dorsal tubercles, keeled, radially ridged, *closely set;* the males with an *interrupted* series of *thirteen* pores on each femur; females without femoral pores; tail bearing whorls of *eight* spines near base, distally six; color *brown* when any is shown; markings when visible *four irregular rings,* shoulders to sacrum, or *marbled;* tail *marbled* with *brown;* rudimentary eyelid scalloped, *no spines;* head *triangular,* width at ears equals snout to *half* way between eye and ear. Redescription based on series of 99 specimens.

Habitat: Porto Rico where I have taken it at San Juan, Río Piedras, Caguas, Humacao, Ponce, Playa de Ponce and Mayagüez.

Proportions: Head triangular, width at ears equals snout to half way between eye and ear; otherwise normal.

Squamation: Rostral much broader than high, squarish, usually with a nick in the posterior margin for the anterior angle of the internasal and a median cleft extending forward for more than one half the height of the shield, in contact with two supernasals; first supralabial in contact with lower post nasal and reaching nostril; *nine* supralabials including the small posterior one, the *series ending* almost under the eye; top of head covered with granules interspersed with small, slightly *elongated, keeled,* and radially ridged tubercles spread about *five* granules apart, there being about *fourteen* tubercles from ear to ear; granules greatly enlarged on snout, especially on rostral canthus where they are about the size of *head* tubercles; eye equidistant between nostril and ear, its diameter being about one half its distance from tip of snout, *no* spines on rudimentary eyelid; ear opening elongate, oblique; mental triangular, as wide as rostral, *eight,* frequently *seven* infralabials, four chin shields, center pair much the larger, irregularly pentagonal, their anterior angle fitting into the corner between mental and *most* of *first* and *as frequently* first and *part* of *second* infralabials, broadly in contact with each other on the median line; several rows of elon-

gated scales border the lower labials. There is a considerable variation in the squamation of the throat and chin. Upper surface of body and flanks and hind aspect of legs covered with granules *like* those of head; upper surface *and flanks* bearing *eighteen* or *twenty,* rarely sixteen, fairly even rows of tubercles, strongly keeled and radially ridged, separated front to rear of same row by from *one and a half* to *six* granules; tubercles about three granules long, *no* wide strip of flank without tubercles; rear aspect of legs bearing scattered tubercles; throat covered with small flat uniform granules strongly contrasting with the imbricate cycloid scales of the rest of the underside and the anterior aspect of the legs and extending along sides of tail and seven or eight rows beyond vent, being *smaller* than the dorsal tubercles; anterior to the vent there is a diamond shaped escutcheon of enlarged scales; in the males three, in the females one, outer series of scales under the thighs is enlarged, and in the males only, the outer scales bear a narrow pore extending across the upper part of the scale, there being about *thirteen* such pores on each femur, the series *interrupted* by one scale at the midline; a longitudinal umbilical scar is *sometimes* discernible, anterior to the escutcheon; fingers and toes free, all with long, compressed angularly raised and clawed distal phalanges; basal dilated portion with lamellae, a *large* single one at distal end of a series of four to seven paired ones; tail subcylindical, a groove above extending from base nearly to tip, upper half covered with striated scales slightly larger than the granules of the back and at the base of tail *four* and sometimes *five* rows of long pointed radially ridged spines in whorls on each side of tail, beyond fourth whorl usually only three rows of spines on a side; whorls about *six* scales apart and spines about breadth of *four* scales, scales surrounding each spine slightly enlarged, tail *not* enlarged at whorls, underside either with a median series of large plates about two to a whorl, *or* a *paired* series of plates *or tongue shaped scales;* a regenerated tail is covered with scales *somewhat larger* than dorsal granules and is without whorls or spines, but does have irregular large median scales on underside and the groove above.

Color and Markings: Color and markings usually show in this species: distinctly brown above and finely dotted below. The illustration shows the extreme in pattern, usually this is broken up into somewhat irregular marbling; all color due to concentration of fine black or brown specks; a distinct transocular dark line bordered above and below with a light line of equal width; lamellae distinctly ash gray; a regenerated tail may be marbled above with brown sim-

ilarly to dorsal pattern. Young: The tail is banded dark and salmon, body frequently not noticeably more pigmented than adult; frequently very dark, the four dorsal rings outlined by light tubercles.

I took a baby *Hemidactylus* 31 October, 1931, by placing my finger tip on his head. He raised his tail and waved it and the end broke off without touching any object. Tail banded black and salmon. Upper surface of body almost black with four rings of light yellow dots, shoulders to sacrum. A few light dots scattered but none within the rings. Specimen taken in broad daylight. By dark it had turned lighter color inside the rings, making four light discs. By 9:30 P. M. he had turned lighter except for four dark rings corresponding to the four rings of yellow dots. The feet were flesh color. By next morning, although kept in a dark drawer, he had turned as dark as when captured. This specimen did not at any time turn any where near as light as specimen No. 3510 taken at night. This last was as light as a "colorless" adult except for the black and salmon rings.

Remarks: When caught by hand this little gecko frequently gives a squeak. Specimens taken 99, of all sizes.

Through the kindness of Dr. Stejneger and Miss Cochran of the National Museum three specimens of *H. brookii* were made available to me for comparison. They appear to be the same species that occurs on Porto Rico, but vary in a few particulars beyond the range of variability of the Porto Rican specimens. Especially are they noticeable in bearing more closely-set and heavier spines in the pelvic region.

The following table brings out a few differences, but it is to be borne in mind that it is a comparison of a series of 99 with three specimens.

Hemidactylus brookii	Porto Rico series of 90 specimens	U. S. N. M. 42507 Uganda, Africa	U. S. N. M. 42175 Wadelai Nile, Africa	U. S. N. M. 28992 Bacow P. I.
Femoral pores interrupted at center by	1 scale	3 scales	4 scales	5 scales
Spines in ear	none or very small tubercles	blunt spine	1 long spine	none
Pattern	typical	typical	typical	obliterated
bare flank strip..... granules in width	3–6	none	none	4–5
mental wider than rostral	no	slightly	yes	much
rows of dorsal tubercles	18	18	18	18
separated by..... granules	1½–6	1–3	2	2–3

HEMIDACTYLUS MABOUIA

Based on a series of 41 specimens.

Diagnosis: A gecko of moderate size, the basal half of each digit expanded and provided beneath with several pairs of lamellae between *small* single ones, the distal half compressed, arising from within the tip of the expanded portion, curved, and provided with a claw at the tip; *twelve* rows of dorsal tubercles spaced from *one* to *four* times their width apart, strongly keeled and radially ridged; the males with an *uninterrupted* series of *sixteen* or *seventeen* pores on each femur; females without femoral pores; tail bearing whorls of *six* spines; color *gray;* when markings are visible six black "V" shaped, point to the rear, cross bands, head to sacrum; tail barred with black at every fourth whorl of spines; one or more small *spines* along rear edge of rudimentary eyelid. Head normal, width at ears equal to snout to *one-third* distance between eye and ear. Diagnosis and description based on entire series of 41 specimens.

Habitat: Vieques and St. Thomas Islands. Found around old buildings at night.

Proportions: More slender than *H. brookii;* width of head at ears equal to snout to one-third distance between eye and ear.

Squamation: Rostral much broader than high, squarish, split nearly to lip, bordered above by supernasals and the anterior of two small scales between the latter; first supralabial in contact with lower postnasal and reaching nostril; about *twelve* supralabials including the small posterior one, the *ninth* under the center of eye; top and sides of head covered with fine granules interspersed with small, *circular,* radially ridged, *unkeeled* tubercles, spaced about *seven* granules apart, there being about *eighteen* tubercles from ear to ear; granules greatly enlarged on snout, especially on rostral canthus where they are nearly the size of *dorsal* tubercles; eye equidistant between nostril and ear, its diameter being about one-half its distance from tip of snout, *one* or *more distinct black tipped spines* on posterior part of rudimentary eyelid; ear opening elongated, oblique; mental triangular, as wide as rostral, *nine* or *ten* infralabials; four chin shields, center pair much the larger, irregularly pentagonal, their anterior angle fitting into the corner between mental and first and *nearly always* part or second infralabials, broadly in contact with each other on the median line; several rows of elongated scales border the lower labials. There is a considerable variation in the squamation of throat and chin. Upper surface of body and flanks and hinds aspect of legs covered with granules *larger* than those of

head; upper surface of body bearing *twelve* fairly even rows of tubercles, strongly keeled and radially ridged, separated front to rear of same row by from *four* to *eight* granules; tubercles about three granules long; a *wide strip* of flank bears *no* tubercles; rear aspect of legs bearing scattered tubercles; throat covered with small flat uniform granules, strongly contrasting with the imbricate cycloid scales of the rest of the underside and the anterior aspect of the legs and extending along sides of tail and seven or eight rows behind vent, being the *size of* or frequently *larger than* the dorsal tubercles; anterior to the vent there is a diamond shaped escutcheon of enlarged scales; in the males three and in the females one outer series of scales under the thighs is enlarged, and in the males only, the outer scales bear narrow pores extending across the upper part of the scales, there being *sixteen* or *seventeen* such pores on each femur, the series *not* interrupted at midline; a longitudinal umbilical scar is visible anterior to the escutcheon; fingers and toes free, all with long, compressed angularly raised and clawed distal phalanges; basal dilated portion with lamellae, a *very small* single one at each end of a series of four to seven paired ones; tail subcylindrical, a groove above extending from base nearly to tip, upper half covered with striated scales slightly larger than the granules of the back and *three* rows of long pointed radially ridged spines in whorls on each side of tail; whorls about *seven* scales apart and spines about the breadth of *three* scales, scales surrounding each spine slightly enlarged, tail *enlarged* at each whorl, underside *always* with a median series of large plates which begins below the seven or eight rows of pointed scales and possibly one or two divided plates, about two to a whorl; a regenerated tail is covered with scales about *four times* the size of dorsal granules and is without whorls, spines, enlargements or large lateral cycloid scales, but does have the large median plates on underside and the groove above.

Color and markings: No sexual dichromatism apparent; most specimens show little color. Whether because they are killed when pigment is not on surface or because of being killed at night I do not know. When pattern shows at maximum; upper surface gray, snout brown, marbled, six black cross lines, head to sacrum, somewhat "V" shaped, point to rear, dorsal tubercles black dotted, a black band at every fourth whorl on tail; no transocular dark line; a regenerated tail is speckled, but no marblings appear. Underside: clear white save for a few minute dots on lower labials and mental and tail; lamellae very dark gray, very noticeably in contrast to underside of body. Young: Same pattern above, but very dark as

a whole, due to fine black dots; underside dark from multitude of fine black dots; labials and side of head noticeably marked with white or cream colored dots.

Remarks: Specimens taken, 34 from Vieques, 7 from St. Thomas.

Through the kindness of Dr. Stejneger and Miss Cochran, of the National Museum, I have been able to study 10 specimens of *Hemidactylus* from each of Cuba 3; St. Thomas 3; Barbados 2; Guadeloupe 1; Antigua 1.

The specimens from Cuba, U.S.N.M. Nos. 75843, 27630–1 catalogued as *H. mabouia* are in reality *H. brookii*. The rest are *H. mabouia*. One specimen U.S.N.M. 11186 differs in having the dorsal tubercles noticeably flat. Otherwise it agrees in all particulars.

Conclusion: I have definitely identified *H. brookii* from Porto Rico and checked specimens from Africa, The Philippines and Cuba as of this species. I have identified *H. mabouia* from Vieques and St. Thomas and checked specimens from Barbados, Antigua and Guadeloupe as of this species.

Careful search has failed to reveal any *Hemidactylus* on Mona, Culebra or Caja de Muertos Islands. The inhabitants maintain that this lizard does not exist on their islands.

NOTE: I am indebted to Miss Adrienne Serrano of Vieques for most of my series from that island, and to Mrs. Heiberger of St. Thomas for the specimens from St. Thomas.

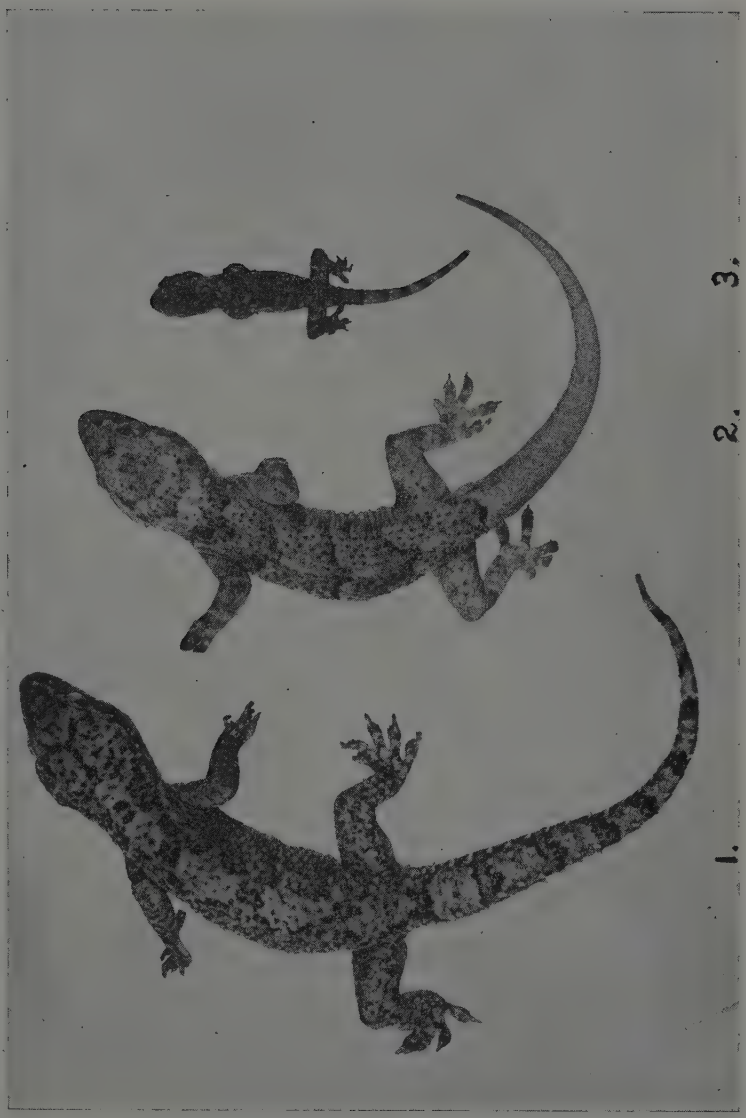
EXPLANATION OF PLATE X

Fig. 1.—*Hemidactylus brookii.* Note pattern of rings and the coarse tubercles.

Fig. 2.—*Hemidactylus mabouia.* Note chevron shaped pattern and small tubercles.

Fig. 3.—Young *H. mabouia.*

PLATE X.



THE INITIATION OF AN INSECT PEST SURVEY IN PORTO RICO *

By M. D. Leonard, Entomologist, Insular Experiment Station, Río Piedras, Porto Rico.

ABSTRACT

A brief account of the initiation of periodic observations and reports on the more important and injurious insects in Porto Rico in cooperation with the Insect Pest Survey office of the United States Bureau of Entomology. Faunal studies, both past and present are referred to and methods of collecting and recording Survey data are described. The objects of an Insect Pest Survey and the benefits to be derived from such work, both local and international, are suggested.

PREVIOUS FAUNAL STUDIES

Basic to an Insect Pest Survey in the strict meaning of the term is a thoro knowledge of what insects occur in the State or Country under consideration. Dr. L. O. Howard once stated that "All entomology is economic entomology." Since this is fundamentally largely if not entirely true, before the injurious or non-injurious nature of all the various species present can be properly evaluated, it is first highly desirable to know just what species comprise the insect fauna and their distribution, both geographical and seasonal. All studies, therefore, that have contributed towards such an end help to lay a valuable foundation for a detailed Insect Pest Survey of the territory.

Much work of this nature has fortunately been done in Porto Rico. The early accounts of Porto Rican insects by Fray Iñigo Abbad in 1788 and Andrés Pedro Ledru in 1810 followed by the extensive collections and studies of Dr. Augustín Stahl published in 1882 and of Drs. Leopold Krug and Juan Gundlach (1887–1893) form the basis of our knowledge of the insects of the Island.

In 1903 a Federal Experiment Station was established at Mayagüez and from then until 1924 several well-known entomologists, notably W. V. Tower, C. W. Hooker and R. H. Van Zwaluwenburg did much to increase our knowledge of the insects of the Island. In 1914 Van Zwaluwenburg compiled a typewritten list of the all insects recorded in Porto Rico to date with a supplement the fol-

* This paper was read before the 3rd Annual Meeting of the Eastern Branch of the American Association of Economic Entomologists held in New York City, November 19–20, 1931.

lowing year. The Sugar Producers' Association established an Experiment Station in 1910 at Río Piedras which was reorganized three years later as the present Insular Experiment Station. For the past twenty years in this Station a great deal of data on Porto Rican insects has been accumulated by a number of well-trained workers, especially Van Dine, T. H. Jones, C. H. Hood, Crossman, Smyth, G. B. Merrill, Cotton, Wolcott, Seín and Dozier. In 1924 Wolcott published his "Insectae Portoricensis" in which he listed all of the insects known to occur in the Island with notes on their distribution and food-plants. In this a total of upwards of 2500 species are mentioned. It is a most useful piece of work.

In 1913 the New York Academy of Science in cooperation with the Porto Rican government conceived a plan of making a complete Scientific Survey of Porto Rico and the Virgin Islands. For several years beginning in 1914 a large number of insects were collected by F. E. Lutz, H. E. Crampton, A. J. Mutchler, C. W. Leng, F. E. Watson, H. G. Barber, L. B. Woodruff and others for inclusion in the reports of the Survey later on. To date a report has been published on part of the moths by Forbes and a report on the Diptera by Curran and a supplement to each has appeared during 1931. The preparation of the reports on most of the other major orders of insects is well along so that in the course of a few years we will have a good basic knowledge of the insect fauna of the Island.

INITIATION OF A FORMAL INSECT PEST SURVEY

All of the above, however, is still not sufficient. In Porto Rico as in all other places we need to know not only what insects constitute the fauna but also the feeding habits of each, its seasonal and geographic distribution and its relative abundance during different parts of the year. Such information can be obtained only by systematic, frequent and continued observations made over a considerable period of time.

The writer has been greatly interested in the Insect Pest Survey conducted under the very able direction of Mr. J. A. Hyslop in the U. S. Bureau of Entomology ever since its inception in 1921 and for the first few years while stationed in New York State was an active collaborator in this work. Shortly after coming to Porto Rico in January 1930 he was appointed an Official Collaborator of the Survey and began to make observations with that end in view. For many years, in fact since 1911, insect records at the Insular Experiment Station had been kept on so-called accession cards, each of which

contains the notes in connection with specimens placed in the collection. Each card bears a serial number of that year corresponding with the same number on the pinned specimens in the collection. The disadvantage of this method of keeping records for the purpose of an Insect Pest Survey is that the accession cards are filed numerically and not by the names of the insects; also that unless notes are accompanied by actual specimens in the collection they really have no proper place in the file. This has made it difficult to determine what observations have been made on any given insect since the close of Wolcott's "List" in 1923 and further it is not necessary or desirable to continue to place specimens of many common and well-known insects in the collection each time an observation is made concerning them.

At the Cleveland meeting of the American Association of Economic Entomologists in December 1930 Mr. Hyslop presented a brief paper showing how any entomologist could institute a simple record system for keeping track of observations on the activities of injurious insects in his territory (See Jour. Econ. Ent. **24**(2) : 463–465, 1931) and offered to supply to anyone desiring them the standard record blanks in use in his office in Washington. Such a set of blanks was therefore obtained and the systematic recording of all observations possible on injurious insects in Porto Rico was commenced early in 1931. The accession card catalog has been kept up at the Station but is now used only where specimens are preserved in connection with individual observations and even in all such cases the notes are also entered on the regular Survey record blanks.

By this system the whole process of recording and filing observations after they are made is surprisingly simple. In this way nothing of value is lost and many new and interesting records have already been obtained. Such records as were accumulated during 1930 (mostly during the second half of the year) were transferred to the standard record blanks and included in the file. Altho the Survey work has been a minor project of the Division of Entomology at the Station and not a great deal of time has been given to it we have been able to record in a little more than a year well over 500 individual observations on nearly 150 species of more or less injurious insects, distributed in over 100 genera. A number of species have been watched from month to month in order to determine more accurately their peaks and low points of activity. This is only the start. Its scope is continually expanding as we work with it.

METHODS OF OBTAINING DATA

The methods of obtaining data are possibly for the most part no more than the obvious ones but they may be worth while mentioning. The two members of the staff at the Station at Río Piedras and Dr. Wolcott at the Sub-Station at Isabela make observations during trips on the Island and also locally on crops grown at or near the two Stations. Conversation or correspondence with at least certain members of the Division of Agricultural Extension in various parts of the Island and with the Superintendents of the Department's Experimental Farms bring to light many interesting notes. General correspondence from farmers and home-owners has also turned up much of value. Beginning July 1, 1931 several Specialists were appointed at the Station to cover work with most of the different crops grown in the Island. These men will make many observations as time goes on in the course of their official travels and indeed have already supplied some very worth-while data. A fertile source of information has been the local office of the U. S. Plant Quarantine & Control Administration whose staff have made many interceptions since 1925 of injurious insects in Porto Rico both in the field and from fruits and vegetables offered for shipment to the Mainland. Such material has all been determined, wherever necessary, by the Specialists in the U. S. National Museum. From July 1930 thru October 1931 these interceptions included over 300 individual records on about 75 species distributed in about 60 genera, most of which were more or less injurious to crops.

Mr. Hyslop has suggested that the object of an Insect Pest Survey is to collect accurate and detailed information on the occurrence, distribution, ecology, and relative abundance of insect pests throughout the territory involved and to study these data from month to month and year to year with relation to the several factors that influence insect abundance. The results to be obtained from a survey of this nature, undertaken for a series of years are manifold; we should be able to throw light on the reasons for the cyclic and sporadic appearance of insect pests, the gradual shift of regions of destructive abundance, the limiting barriers to normal dispersal and the directive influences that determine the paths of insect diffusion. This is the necessary foundation for any advance toward the possibility of entomological forecasting.

THE BENEFITS OF INSECT PEST SURVEYS

To further expand this suggestion: An attempt is being made to complete a picture. This is a mosaic however and as the years go on each record supplies a tile which fits into its proper place to help make up the whole. If enuf records could be obtained in a sufficient number of places with varied conditions and taken over a sufficient period of time much light would undoubtedly be shed upon insect activities which would prove of increasing practical value as time went on.

Intensity maps could be gradually filled out which, if properly correlated with temperature, humidity and rainfall would go far to show the effect of these factors on insect abundance. Further: altho breeding is more or less continuous in many places thruout the Tropics, it is well-known that in Porto Rico and also certain other places some insects, at least, are more abundant during the summer months, while others are more numerous in the winter season. This is in spite of the fact that the average mean temperature in Porto Rico, for example, varies but little from month to month. Reliable and continued observations on certain selected insects would do much to explain this phenomenon. Such observations should of course be correlated with data on the seasonal abundance of favored food-plants and other pertinent factors.

A more immediate value of Survey work is possibly the building up of definite data on the infestation of certain crops, positive or negative, which at once becomes of considerable value when plant quarantine questions arise. This has been shown very clearly during the past two years in Porto Rico and in those cases where sufficient conclusive evidence was lacking we wished greatly that a systematic Insect Pest Survey as such, had been in progress for a much longer time.

The writer has supplied to the office of Insect Pest Survey in Washington, besides a monthly report on insect conditions in Porto Rico, a summary report for both the fiscal years of 1929–30 and 1930–31. The former was published in the Annual Report of the Division of Entomology of the Insular Experiment Station for that year (pp. 110–123, 1931) and the latter will be published in the Jour. Dept. Agr. Porto Rico, **16** (2) for April, 1932. This could also be done in other places to the great mutual advantage of both the Country concerned and the United States. If periodic monthly or bi-monthly, or even semi-annual or annual reports could be prepared by a competent person in a number of foreign countries and a copy

sent for file in the office of Insect Pest Survey in Washington in exchange of the monthly bulletin of that office a great mass of most valuable data could be accumulated of benefit to all concerned.

Such periodic reports should be encouraged and the necessary cooperation obtained from the proper officials, especially to start with in those countries which export the greatest variety of fruits and vegetables and other crops to the United States. It is encouraging to note that for the first time since the start of the Federal Insect Pest Survey reports have been received and published during this past year in the Insect Pest Survey Bulletin from places outside the mainland of the United States. These include one or more each from Hawaii, Mexico, Cuba, Honduras, Guatemala, Costa Rica, Haití, Dominican Republic, Antigua (B. W. I.) and China in addition to Porto Rico. I understand from Mr. Hyslop that cooperation is now being solicited in addition to the above, from Peru, British Guiana, the State of Minas Geraes in Brazil, as well as several of the British West Indies for Survey reports during the coming year.

Regular commercial travel by airplane between the mainland of the United States and the West Indies and Central and South America is growing so rapidly that it is sure to greatly increase trade in plants and plant products with the United States. This will obviously augment plant quarantine problems and increase the necessity for a more accurate knowledge of the insect pests of all the countries concerned. Well-organized Insect Pest Surveys will supply the necessary information. They will of course be of value insofar as they are conducted with consistency and thoroness but any and all information that is accumulated will be well worth the effort spent in obtaining and recording it.

THE PINK BOLLWORM OF COTTON IN PORTO RICO *

By M. D. Leonard, Entomologist, Insular Experiment Station, Río Piedras, Porto Rico.

ABSTRACT

The introduction, spread and present status of the pink bollworm, *Pectinophora gossypiella* Saunders, in Porto Rico are described. In order to understand the somewhat unusual conditions under which the insect is working in the Island the essential climatic and topographic features and the development of Sea Island cotton growing in Porto Rico are briefly outlined. Attempts at control are discussed together with the relation of alternate host plants as a factor in carry-over of the insect from one crop to another.

CLIMATE AND TOPOGRAPHY

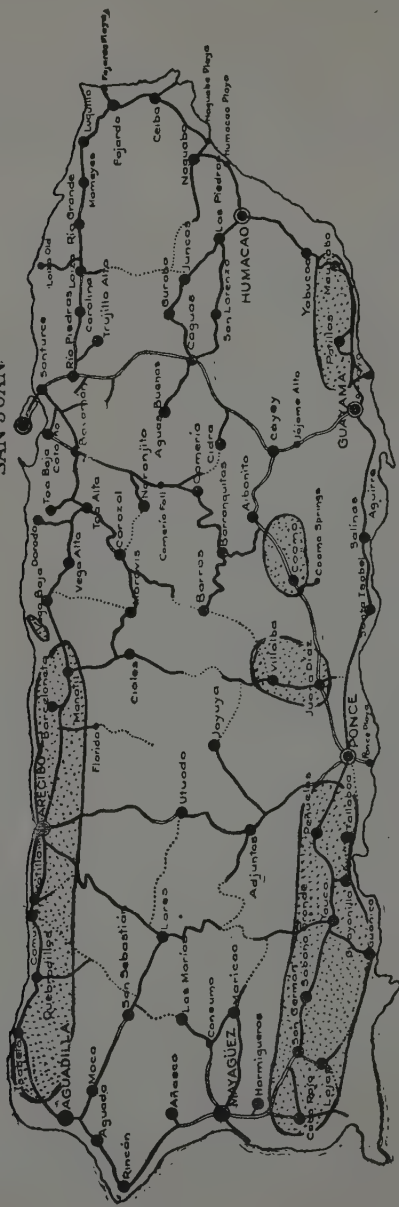
In order to gain an intelligent understanding of the pink bollworm problem in Porto Rico it is desirable to know something of the essential climatic and topographic features of the Island and of how the Sea Island cotton crop is grown there.

Porto Rico is about 90 miles long by 40 miles wide with an area of nearly 3600 square miles. It is roughly rectangular in shape. the long axis being East and West. In general the whole Coastal area is an irregularly narrow, fairly level strip, but the Island is for the most part very hilly, with a central chain of mountains running lengthwise, but nearer the South Coast, several peaks of which rise to over 4000 ft. above sea-level. The mean annual temperature is about 78°F. for the Island as a whole, there being but little difference between winter and summer temperatures. The rainfall for the whole Island averages about 71 inches for the year but differs greatly in different sections: the South Coast having about 45 ins. and the North Coast about 65 ins. The trade winds blow almost continuously in an easterly direction, thus concentrating the rainfall in the sections North and East of the mountains.

COTTON IN PORTO RICO

There are two distinct cotton growing regions in Porto Rico—the North Coast and the South Coast sections. The North Coast section extends in an almost continuous strip from Aguadilla at the Northwest corner of the Island as far as Arecibo and in more spotted

* This paper was read before the 44th Annual Meeting of the American Association of Economic Entomologists held at New Orleans, La., December 29–31, 1931.


SAN JUAN
HUMACAO
GUAYAMA
PONCE
AGUADILLA
MAYAGÜEZ
ARECIBO
Barceloneta
Manatí
Florida
Utuado
Joyuda
Cabo Rojo
Lajas
Guánica
Yauco
Guayanilla
Peñuelas
Juana Díaz
Coamo
Coamo Springs
Aguirre
Salinas
Arroyo
Patillas
Maunabo
Yabucoa
Naguabo
Ceiba
Fajardo
Luquillo
Río Grande
Loíza
Canóvanas
Carolina
Trujillo Alto
Río Piedras
Santurce
Bayamón
Cataño
Guaynabo
Toa Baja
Toa Alta
Dorado
Vega Alta
Vega Baja
Morovis
Corozal
Naranjito
Comerío
Barranquitas
Aguas Buenas
Cidra
Aibonito
Caguas
Gurabo
Juncos
Las Piedras
San Lorenzo
Ceiba
Naguabo
Humacao
Cayey
Aguada
Moca
Añasco
Rincón
San Sebastián
Las Marías
Maricao
Hormigueros
Sabana Grande
Boquerón
Cabo Rojo
Lajas
Guánica
Yauco
Guayanilla
Peñuelas
Adjuntas
Jayuya
Utuado
Ciales
Manatí
Barceloneta
Arecibo
Florida
Barceloneta
Manatí
Ciales
Morovis
Corozal
Naranjito
Comerío
Barranquitas
Aibonito
Cayey
Caguas
Gurabo
Juncos
Las Piedras
San Lorenzo
Humacao
Naguabo
Ceiba
Fajardo
Luquillo
Río Grande
Loíza
Canóvanas
Carolina
Trujillo Alto
Río Piedras
Santurce
Bayamón
Cataño
Guaynabo
Toa Baja
Toa Alta
Dorado
Vega Alta
Vega Baja
Morovis
Corozal
Naranjito
Comerío
Barranquitas
Aguas Buenas
Cidra

patches eastward almost to Vega Baja, being confined to the more level coastal lands. In the South Coast the principal section is from Cabo Rojo at the Southwest corner westward almost to Ponce. This is mostly at a fairly low level near the coast. This past year considerable cotton was also grown at Patillas and Maunabo, both near the coast. There are however important plantings at Villalba and Juana Díaz and at Coamo which are at higher elevations. Cotton was grown in 1931 at Villalba at at least 600 feet elevation, which is undoubtedly the highest point at which Sea Island cotton has ever been cultivated anywhere in the world. (See accompanying map showing cotton-growing areas in 1930–1931.)

Only Sea Island cotton is grown. This type was first cultivated commercially in Porto Rico, along with several other types in 1861 due to reduced acreage in the United States on account of the Civil War. Various types of cotton have however been long grown in Porto Rico and the plant was cultivated by the aborigines prior to the arrival of Columbus in 1493. In 1736 sugarcane, coffee and cotton were the three most important crops and in 1776 over 100,000 lbs. of cotton were produced. In 1837 it is stated * that a little over 1 million pounds of cotton were shipped out of the Island. This production greatly declined during the ensuing years however due to increase of the crop in the Southern United States.

Since 1924 there has been a steady increase in acreage in the North Coast from 6500 acres to 1100 in 1931. In the South Coast however there were about 5000 acres yearly from 1924–26; it fell off greatly in 1927 but was up to 4500 acres in 1930 and in 1931 increased to 9,000 acres, thus making a total of 20,000 acres for the Island as a whole. This makes Porto Rico the largest Sea Island cotton growing section in the world.

For several years now all the cotton has been grown under contract for the San Juan Ginnery Co. which is subsidiary to J. & P. Coats Ltd. of Glasgow and the Clark Thread Co. of Newark, N. J., for export. The Company provides free seed and advances money for fertilizers, insecticides and cultivation expenses to the growers, all advances being deducted from the returns from the crop at harvest time.

THE PINK BOLLWORM SITUATION

The pink bollworm was first discovered in Porto Rico in July 1921 at Humacao at the East end of the Island. An immediate sur-

* By Fray Iñigo Abbad y Lasierra in his Historia Geográfica, Civil y Natural de la Isla de Puerto Rico, p. 326, Madrid, 1788 (New Edition, Acosta, Porto Rico, 1866).

vey following its discovery showed that the insect was present in all the important cotton growing sections. In the spring of 1922 the infestation was practically confined to the coast or its immediate vicinity but a year later infested plants (mostly wild cotton) could be found considerably inland in several sections.

The insect is thot to have been introduced with seed brought from St. Croix in 1920 which was widely distributed thruout the Island.

As far as can be determined the pink bollworm, altho present in all the cotton growing areas in the Island since 1921–23, was not any appreciable factor in the production of the crop until 1931. It is stated that the late crop in 1925 around Aguadilla was damaged from 3–5 per cent. In the crop harvested in 1930, for example, a light infestation could be found in many fields but this was mostly confined to the last picking and did but little damage. In 1931, however, caterpillars were present in almost the first picking of the earliest fields observed during the fore part of January in the South Coast. Continued observations showed that the infestation increased until by the end of the crop in April and early May many fields could be found in the South Coast with as high as 95 to even 100 per cent of the bolls infested. It is estimated that there was at least a reduction of 15 to 20 per cent of the crop on account of the pink bollworm and it actually was probably even greater than that.

In the North Coast section the situation was somewhat the same and for the first time also. One very early planted field examined at Hatillo on May 5, 1931 was so badly infested at the time that it was reported to have been practically worthless two weeks earlier. Another field, for example, near Aguadilla showed a high infestation in the first crop in June, often two or three caterpillars being found in one boll or a large caterpillar in a small boll.

ALTERNATE HOST-PLANTS

The question of alternate host-plants is an important one in Porto Rico since they produce fruit continuously thruout the year thus making possible continuous breeding of the pink bollworm thruout the year. Wild tree cotton is rather thinly but widely distributed thruout all sections despite several previous efforts to eradicate it. Especially in the South Coast it is a constant menace to the cultivated Sea Island crop, where less thoro clean-up work has been done than in the North Coast cotton growing sections.

In 1923 it is reported that the then Agricultural Agent in Camuy found the fruits of the maga tree, *Montezuma speciosissima* infested by pink bollworm larvae. Apparently almost no further ob-

servations on this tree as an alternate host were made until this past year. On May 5, 1931 Mr. U. C. Loftin and the writer collected 50 fruits from a tree near Aguadilla of which 2 were infested, each containing a live larva. Dr. Geo. N. Wolcott states that early in October, after most of the crop had been harvested he found maga fruits as high as 70 per cent infested, with often two or three larvae to a fruit. This tree is undoubtedly an important factor in maintaining the pink bollworm population between one cotton crop and another. It is common at the lower elevations, especially in the Central and Western parts of the Island. It has been extensively planted along the main coastal roads for ornament and shade, since it has showy crimson flowers and large dark green leaves and often reaches a height of 40–50 feet. The fleshy fruits form thruout the year. Besides being used for shade and ornament the wood is said to be used for furniture, musical instruments, posts and the like and it is claimed that hardship would be caused by having these trees destroyed in the cotton growing areas.

Another Malvaceous tree, locally called the "emajaguilla," *Thespesia populnea,* is also an alternate host of the pink-bollworm but it is of relatively minor importance. Mr. Loftin and the writer examined fruits in several localities on May 4 and 5, 1931, with negative results but one sample of 50 fruits collected near Yauco on May 4 had one which contained a live bollworm. This tree is more common in some sections of the Island than the maga and grows well up in the mountains as well as in the coastal sections along the main roads. It seems to have a more definite fruiting period than the maga.

During the past year it has been established by inspectors of the U. S. Plant Quarantine & Control Administration and by Dr. G. N. Wolcott that okra growing near badly infested cotton is liable to infestation. Dr. Wolcott's observations further show that even the very small marketable pods only a few days old, become infested when the plants are growing near badly infested cotton but that infestation does not occur when the cotton is only moderately infested.

ATTEMPTS AT CONTROL

Very soon after the discovery of the pink bollworm in Porto Rico a project was outlined to destroy all the wild tree cotton, especially in the Eastern end of the Island—the original place of the discovery of the insect, but was abandoned when the distribution of the pink bollworm was found to be so extensive.

Since that time all cotton seed has been fumigated at the San Juan Ginnery Company's gin at Martín Peña, which is the only gin in use on the Island. The standard carbon bisulfide treatment has been used at the rate of 1 lb. per 80 cu. ft. for at least 24 hours. The fumigation rooms are tight and the work is done under the immediate supervision of an inspector of the Insular Plant Quarantine Service. As far as we have been able to determine this fumigation has always been highly effective.

As before stated it has been estimated that at least part of the crop of 1925 was damaged from 3–5 per cent. During this year the Porto Rican Legislature passed a law empowering the Commissioner of Agriculture to declare cotton a public nuisance during certain specified periods of each year. These were set as follows: for the South Coast from May 15 to July 30 and for the North Coast from October 15 to December 31. This law provided for the destruction of all Sea Island cotton by the start of the "closed season" and wild cotton was declared to be a public nuisance during any time of the year.

Some effort has been made each year since that time to carry out this law but for various practical reasons only partial success has been obtained. The great increase in the amount of damage to the crop, harvested in 1931, however, greatly stimulated efforts to make the closed season for Sea Island cotton and the destruction of wild tree cotton more effective. A series of meetings were held in each of the ten principal cotton growing towns in the South Coast the week of April 20th. These were well attended by the cotton growers and at each meeting representatives of the Insular Experiment Station, of the Agricultural Extension Division and of the San Juan Ginnery Co., attempted to explain exactly the meaning of the closed season and the reasons for it. Despite this effort on the part of those charged with the wellfare of the cotton growers, success was only partial. It was estimated that by May 15, the date set for the start of the closed season and therefore of the completion of the destruction of the old crop, only about 5 per cent of the old crop remnants had been destroyed. By June 1 about 50 per cent of the old plants had been pulled out and destroyed and it was not until the end of the month that the work was anything like even fairly well accomplished. Little had been done by that date however in the Guayama–Maunabo section where the crop had been planted late. Wild cotton had been cut down and destroyed to a large extent but in some places little had been done by the end of June and much still remained even by November 1st. It is thus seen

that the theoretical "no cotton" period of three and half months was cut down to at best not more than one month and even at that a great many wild tree cotton plants were never destroyed at all.

In the North Coast the closed season for 1931 was advanced to October 1 this year and altho the growers in this section have always been more progressive, since they have been more dependant on cotton as a cash crop, the results to date have been far from satisfactory. It is estimated that by October 20 about 75 per cent of the old cotton plants have been pulled out but of these only about one-third have been burned. Very little of the clean-up work had been accomplished by October 1st but this was said to be because of the understanding among many growers that the closed season was not to start until October 15 as previously agreed. The clean-up has apparently been good in Camuy and fairly complete in Isabela but poorest in Hatillo and Vega Baja, which latter two localities were undoubtedly the worst infested during this past year.

Due primarily to differences in the distribution of rainfall but also to differences in the distribution of available labor the planting, growing and picking seasons for cotton are quite different in the two principal sections. This is shown in the following table.

TABLE 1

SHOWING PLANTING, PICKING AND CLOSED SEASON IN THE COTTON AREAS OF PORTO RICO

(PREPARED BY J. PASTOR RODRIGUEZ).

Cotton Section	Planting	Picking	Closed Season
North Coast.....	January, February and to March the 15th	June, July, August and September	From October 10 to January the 1st
South Coast.....	August and September.	February, March, April and May	From May 15 to August the 1st.

Because of the difference in planting season in the North and South Coasts commercial plantings of cotton are growing in the Island during every month in the year. It has therefore been most emphatically suggested by Mr. Loftin, during this past year that the planting season by synchronized in both the North and South sections, thus permitting a "no cotton" season for the whole Island at the same time. This is highly desirable if not absolutely essential to successful pink bollworm control but for various practical and economic reasons it seems impossible of accomplishment at present. In such an event, however, it would probably be best for the North Coast to change to the planting season of the South Coast but the seasonal distribution of labor and of alternate crops seem to be strongly

against making such a radical change. Another alternative advanced is that the South Coast abandon the growing of cotton entirely. This many growers do not wish to do even with a price of not more than 6¼ cents a pound guaranteed for first grade-seed cotton for 1932.

It has recently been proposed to take a holiday from cotton growing in the Island for 1932 but neither does this proposition does find favor among many growers and also the crop in the South Coast had already been planted.

For various practical reasons, therefore, the successful carrying out of possible measures for the suppression of the pink bollworm looks rather dubious and it is anticipated that considerable loss to the crop may result during the coming year. There have been planted only about 1400 acres in the South Coast for the coming crop as against 9000 acres this past year and it is estimated that the North Coast crop will be much less than the acreage of 1931. The pink bollworm infestation has built up to an alarming extent during the past year and for this coming year there may be at least as many if not more worms present to infest less than one-sixth of the previous acreage in the South Coast and not more than one-half the previous acreage in the North Coast.

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1931. **Leonard, M. D.** Report of the division of entomology *in* Ann. Rept. Ins. Exp. Sta. P. R. for 1929–1930, pp. 114, 119.

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1931. **Loftin, U. C.** Preliminary report on the pink bollworm situation in Porto Rico, 15 pp. (A typewritten report prepared shortly after a visit of several days to Porto Rico the first week in May, 1931.)

1931. **Pastor Rodríguez, J.** Alarmante irrupción de la oruga rosada del algodón en el distrito sur. Rev. Agr. P. R. **26** (9) : 174, 176.

1931. **Torres, I. L.** Campaña contra el gusano rosado del algodón. Rev. Agr. P. R. **26** (9) : 175–176.

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1931. **Wolcott, G. N.** The infestation of young okra pods by pink bollworm in Porto Rico. Jour. Dept. Agr. P. R. **15** (4) : 395–398.

ADDITIONAL REFERENCES TO THE BEAN LACE BUG

By M. D. LEONARD,
Entomologist, Insular Experiment Station, Río Piedras, P. R.

In the Journal of the Department of Agriculture of Porto Rico **15**(3) : 309–323 there was published a paper by M. D. Leonard and A. S. Mills entitled "Observations on the bean lace-bug in Porto Rico". A bibliography of 44 titles was included which was intended to be as complete an index as possible to *Corythucha gossypii* Fab. in literature. Mr. S. C. Bruner, Chief of the Department of Phytopathology of the Cuban Agricultural Experiment Station has been good enough to call our attention to several references which we overlooked. They are as follows:

Anonymous (presumably J. R. Johnston). El insecto que ataca la higuereta y modo de combatirlo. Rev. Agr. Com. y Trab. (Cuba) **1**(10) : 531–533, 2 figs. October, 1918.

An official report by the Comisión de Sanidad Vegetal (now Sección de Sanidad Vegetal) on *C. gossypii* as a pest of the castor oil plant, control experiments are included; the adult is figured and spraying operations are shown in a photograph; nicotine sulfate and soap were used successfully.

Barthe, A. E. Cultivo industrial de la higuereta, Rev. Agr. Com. y Trab. (Cuba) **2**(3) : 93–95. March, 1919.

The secton relating to pests of the castor oil plant includes *C. gossypii* as an important pest; evidently largely compiled from previous work.

Bruner, S. C. Un honguillo parásito del Tingítido de la higuereta. Rev. Agr. Com. y Trab. (Cuba) **2**(5) : 218–219, May, 1919.

Relative to the fungus, *Sporotrichum*, parasitic on *C. gossypii* on the castor oil plant.

Bruner, S. C. Informe del departamento de entomología y fitopatología. Ejercicio de 1929 a 1930. Est. Exp. Agr. Cuba, p. 28.

Mentioned as a lima bean pest.

Cardín, Patricio. Plagas de la higuereta en Cuba. Rev. Agr. Com. y Trab. (Cuba) **1**(10) : 527–531. October, 1918.

Largely concerning the *Corythucha*, a serious pest of the castor oil plant; also lists the insect, in their order of being attacked, on: red pepper, soursop, peanut, kidney bean (fríjol) squash, ramie and aguinaldo (*Turbina corymbosa* (L.) Raf.).

Cardín, Patricio. Informe del departamento de entomología y patología de 1917 y 1918. Est. Exp. Agr. (Cuba) pp. 460–461. 1919.

In the report of the Department of Entomology experiments are mentioned for the control of *C. gossypii* on castor oil; soap is effective.

Mr. Bruner also writes that he has taken *C. gossypii* in small numbers on the leaves of banana in addition to some of the plants mentioned in the paper by Mr. Mills and myself.